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The Sixty-Fifth Meeting of the American Astronomical Society

By DEAN B. McLAUGHLIN

The American Astronomical Society held its sixty-fifth meeting in Philadelphia, Sunday to Tuesday, December 29 to 31, 1940, on invitation of Dr. Henry Butler Allen, Director of the Franklin Institute, and Professor Charles P. Olivier, Director of the Flower Observatory of the University of Pennsylvania. Like the previous winter meeting at Delaware, Ohio, this was a joint meeting with the American Association for the Advancement of Science. But, save for the retiring address of the chairman of Section D, and the fact that the Secretary and a few other loyal souls paid their respective dollars at the registration desk at the Bellevue-Stratford, the Association might as well have been a thousand miles away.

The Robert Morris Hotel was the headquarters of the Society. It is located on the outer fringe of the central business section of the city, on the Parkway, and convenient to the Franklin Institute where the scientific sessions were held. Members started arriving early Sunday afternoon. A few were already on hand when the Secretary and R. C. Williams arrived, a few hours earlier than they had expected to, thanks to favorable weather and the saving of time effected by the new Pennsylvania Turnpike. So, in spite of getting lost once or twice in the outskirts of Philadelphia and going the wrong way on one of the doubly-infinite set of one-way streets, they reached the hotel early in the afternoon and met Dr. H. R. Morgan at the door. After getting established in their rooms, they went out for a belated lunch, and a visit to the Association headquarters.

On his return the Secretary found a note under his door: "Room 811, at your convenience, Stebbins." Taking this literally, the author plugged in the radio, with the idea of finding something to put him in the proper mood for the conference. He was somewhat startled to hear a familiar voice asking a question about the orbit of Pluto, and another familiar voice giving the answer. This seemed like the best possible excuse for postponing the conference with the President, so the next ten minutes were spent in absorbing information about the deviations of the planets from their tabular positions, as Dr. Morgan answered Marshall's questions.

The conference of President and Secretary on Society business lasted nearly until suppertime and was then put aside for lighter conversation

during supper at Horn and Hardart's. The first meeting of the Council took place that evening, beginning at 8:00 o'clock. The members retired exhausted at 11:30, leaving some unfinished business for the Tuesday morning meeting.

The first session for papers was held in the lecture hall of the Franklin Institute on Monday morning, and was begun quite promptly at 9:00 o'clock as scheduled. Dr. Allen, Director of the Institute, welcomed the Society and President Stebbins responded. There were 16 papers scheduled for that session, and all of them were presented. An interval-timer warned each speaker when only one or two minutes remained, and practically all finished on time or ahead of time. A few would have taken more time if they had been given a chance, but as one member put it: "When [blank] looked appealingly at Stebbins and Stebbins told him he could make his last remarks in answer to questions during discussion, I knew the crisis had passed!" Similar management during all the sessions resulted in the presentation of all but three papers on the regular program and several on the supplementary list.

The afternoon session was a short one. At the end of it Dr. George W. McClelland, Provost of the University of Pennsylvania, welcomed the Society to the University. President Stebbins again responded. The rest of the afternoon was spent in extra-curricular activities. First the members visited the Flower Observatory where they were guests of Professor and Mrs. Olivier at a reception and tea. From there some went to the Cook Observatory which was recently acquired by the University under the will of the late Dr. G. W. Cook. The trip from central Philadelphia out to the observatories was made in members' cars, for the most part, with seven or eight people compressed into five-passenger vehicles. The Secretary had to drive, and thus missed the chance of holding a lady member on his lap.

The members returned to the city for dinner. One hand-picked group had an excellent shore dinner at the Old Bookbinders' Restaurant. Later there was a special demonstration of the Fels Planetarium, and afterwards refreshments were furnished by the Rittenhouse Astronomical Society.

Tuesday began with a Council meeting at which the unfinished business was cleared up or delegated to committees. The President and Secretary then breathed more easily, since an extra session of the Council would not be necessary.

The morning session for papers was devoted chiefly to a symposium on "Intrinsic Stellar Variation." Dr. Fred L. Whipple who had organized the symposium presided at this session. First on the program were four short papers by members of the Mount Wilson staff: Adams, Joy, Merrill, and Sanford, on various phases of spectroscopy of variable stars, presented by Dr. Shapley. The rest of the program consisted of papers by McLaughlin, on spectra of semi-regular variables, and by

Schwarzschild, on recent studies of the pulsation theory. The symposium was distinctly profitable, and represented some real progress in variable star astronomy. At the end of the session there was time for a couple of papers from the supplementary list. If the author's memory has not slipped a cog, it was at this time that Stebbins was making some announcements and was shut off by the interval-timer which he had left running. A few members who recalled a practical joke that was perpetrated at Ann Arbor suspected the Secretary of having a hand in this incident. Actually he was guiltless, but wishes he weren't!*

The photograph was taken immediately after the end of the session. There was no opportunity during the meeting for identification of faces in the picture, hence there are several unknowns because there was not sufficient time before the "deadline" to permit extensive inquiries. Several identifications depend on a comparison with the pictures of previous meetings. If any errors have been made, the victims are at liberty to feel complimented or insulted, as the case may be, but it serves them right for thinking the Secretary is clairvoyant.

Dr. R. R. McMath, Vice-president of the Association, and Chairman of Section D, presided during the earlier part of the Tuesday afternoon session. Dr. Everett I. Yowell, retiring Chairman, delivered his address on "The Motions of the Stars." The program of papers was then resumed and all except a few on the regular program were presented. Certain papers which involved a number of pictorial slides were deferred to an evening session.

The afternoon session was concluded rather late. On the way back to the hotel a few members tried to pick out Cunningham's comet low in the west near Altair, but with doubtful success. No two could agree on its precise position. Philadelphia meetings are memorable partly for the presence of uninvited celestial visitors; it may be recalled that in 1934 a crowd of astronomers blocked traffic while they made visual estimates of Nova Herculis.

At seven o'clock the group reassembled in the Graphic Arts Section of the Institute for the Society dinner. Between courses an experiment in probability was tried. After the singing of "Happy birthday to you" any person whose birthday fell on December 31 was supposed to rise. After one attempt which failed because half of the people at one table thought they were born on that day, a second trial brought a genuine response from a lady who stood up just long enough to be noticed by those who were quick. During the dessert she composed a poem which was to be transmitted to Dr. Aitken whose birthday also fell on that date. We forgot to inquire whether or not she ate her dessert, but for completeness of the record here is the poem:

*It should be remarked, in the interests of accuracy, that the writer was not the perpetrator of the joke, but admits having been an accessory. He is saving the slide of Dopey for future use.

This is the last day of the year
And to be born on it seems very queer
But the double A. S.
Claims the chance laws a mess
And wishes us both birthday cheer.*

After the dessert and coffee, President Stebbins arose and informed the assembled multitude that he was going to deliver his inaugural address. In the course of it he stated that he had travelled 50,000 miles to astronomical meetings and had listened to a thousand papers: these were two of his qualifications for the office. Actually these figures date from an undetermined time when he stopped counting; the true values, as of 1940, are not at hand.

The inaugural address was rather brief, and he passed on to the principal business of the occasion: the award of the Annie J. Cannon Prize to Miss Julie Vinter Hansen of the Royal Observatory, Copenhagen. The presentation speech was made by Dr. Russell. Unfortunately Miss Vinter Hansen was unable to attend the meeting, but found it necessary to remain at Berkeley. The Secretary acted as proxy for her, to the extent of receiving the medal from the President. In lieu of a speech of acceptance by Miss Vinter Hansen, the President read a letter from her. He did very well too, considering that according to his statement he was translating it from Danish. However, the Secretary had a letter from her which was written in flawless English! The two previous recipients of the award, Mrs. Gaposchkin and Mrs. Sitterly, were present at the speakers' table. After the presentation ceremony Mrs. Sitterly read a resolution of thanks to our hosts, which was adopted by acclamation.

The company then retired downstairs where those who had not had enough attended the extra session at which slides of the planets in light of different colors, by E. C. Slipher (presented by V. M. Slipher) were exhibited, as well as photographs of Cunningham's comet by Cunningham and Watson, and the planet Venus at inferior conjunction, by J. B. Edson and associates.

The group then gradually dispersed. Some went to New Year parties, and others sought peace and quiet. The author, accompanied by two of the ladies (including the one whose birthday was being celebrated) saw to the sending of the poem by telegraph to Dr. Aitken. This involved a trip to Broad Street Station and return, through the crowds of New Year merrymakers, but they arrived at the hotel intact about half an hour before 1941.

Officially the meeting ended with the dinner and the session on Tuesday evening. Wednesday morning, however, a small group met at the Planetarium for a conference on the teaching of astronomy. Several topics were discussed and ideas exchanged. At the end of the conference there was a short unexpected planetarium demonstration when Dr.

*"Both" was later changed to "all" when it developed that a non-member who was present also was born on that day.

Marshall made ready for his afternoon lecture and incidentally initiated the author into the mysteries of the control board.

In the meantime, some other members watched the Mummers' parade on Broad Street. It was a beautifully clear day, as fine as one could ask for. The author spent the remainder of New Year's Day calling on relatives and friends near Philadelphia. On the following day, rather late in the morning, he headed westward in weather as bad as the previous day had been good. Rain fell in torrents most of the way across Pennsylvania, but it did not materially interfere with travel on the Turnpike from Harrisburg to Pittsburgh. It was still possible to take the curves at speeds that would be suicidal on any other road of the region.

No attempt will be made to summarize the papers which were presented at the meeting. There were 61 altogether in the list as it was finally approved by the Council. Solar system astronomy received somewhat more attention than at some recent meetings, thanks to the representation from the Naval Observatory, and some others. Ten new members were elected to the Society by action of the Council.

During the sessions three or four of the wives who attended spent most of the time knitting,—a reminder that we are not altogether aloof from events in Europe. The author shudders at some of the woolen atrocities of 1917-18 and hopes they are not being repeated. Without intending any personal reflections he thought of Madame Defarge as he watched the simultaneous progress of science and sweaters. But no heads were taken off, except perhaps figuratively during discussion.

The next meeting will be held in September, 1941, at the Yerkes Observatory, and the following winter meeting will take place at the Warner and Swasey Observatory, Cleveland.

This is the eleventh meeting the writer has reported in these pages, and with it his supply of "gags" seems to be running low. However, some of the first ones are by this time so old that they would probably be new to a younger generation, and it may be necessary to apply this principle some time. So he hopes that not too many of his readers will take him seriously enough to look up the reports of past years. There are some things in the past that are better forgotten.

Ann Arbor, Michigan, January 13, 1941.

Annular Eclipses of the Sun Visible in the United States in the Twentieth Century

By CHARLES H. SMILEY and FREDERICK W. HOFFMAN

In the twentieth century, seven annular eclipses were scheduled to be seen from the United States and an eighth will just miss being seen here in the annular phase. Four of the seven have already occurred in the first forty years of the century; three remain for the next sixty years.

The first of the seven took place on June 28, 1908. The annular phase was visible in this country only from a region about a hundred miles wide across Central Florida. From a point near Tampa, the annular phase occurred about 10:45 A.M., E.S.T., and lasted 3 minutes 50 seconds. The sun was then about 66° above the horizon.

The next annular eclipse in the United States occurred on November 22, 1919. The annular phase was seen only for a brief time near sunrise from points near the line from Midland, Texas, through Austin, Texas. The sun was only about four degrees above the horizon at the point where the path of annularity moved into the Gulf of Mexico. There the annular phase lasted slightly more than seven minutes, and the path was about 250 miles wide.

On April 28, 1930, there was an eclipse of the sun which was total over a very narrow region in California, Nevada, Idaho, and Montana, and which became annular as the shadow moved northeastward into Canada. The path of totality was only about three quarters of a mile wide at its widest and totality lasted only a little over a second. In California, the sun was practically on the meridian during the total phase and at an altitude of about 62°. Parties from Johns Hopkins University and the Lick and Mt. Wilson Observatories observed this eclipse from sites in California.

The path of annularity of the eclipse of April 7, 1940, entered the United States near San Antonio, Texas, passed along the Gulf Coast, along the Florida-Georgia line, and out into the Atlantic. The path varied in width from 155 miles in Texas to 162 miles near the Atlantic Coast; the corresponding durations of the annular phase were 6.5 and 5.8 minutes, while the altitudes of the sun were 42° and 20°, respectively. Parties were sent from the Hayden Planetarium and the McDonald and Ladd Observatories to observe this eclipse.

For the three coming annular eclipses, the paths of annularity and other circumstances have been computed using Schoch's elements[1] which are somewhat more precise than those given in Oppolzer's "Canon der Finsternisse." It seems worth while to mention again that points on the central line of totality or annularity calculated from the elements given in Oppolzer's "Canon" are likely to be near the truth while maps based upon those in the back of the "Canon" are likely to be seriously in error.[2]

Within the year, a "revised" edition of an elementary astronomy text has appeared with a map showing the paths of coming total eclipses in North America. This map indicates that the path of totality of July 20, 1963, will miss Maine altogether and that the path of totality of March 7, 1970, will lie a hundred miles or so off the Virginia and Carolina coast. Actually the 1963 path of totality *will* cross Maine and the 1970 path will pass through Lake Joe, Florida, Waycross, Georgia, Marion, South Carolina, Goldsboro, North Carolina, and Norfolk, Virginia.[3] A recent recomputation of the 1970 eclipse based on Schoch's elements confirms this statement.

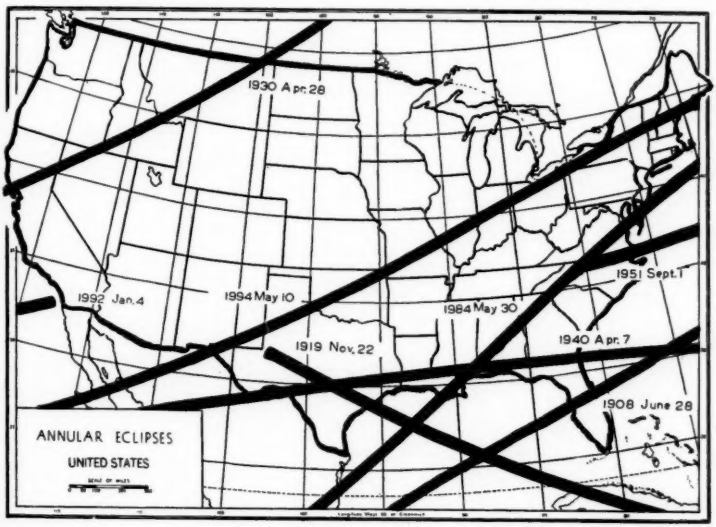


FIGURE 1

At sunrise on September 1, 1951, from points near Elkin, South Carolina, the sun will be seen in annular eclipse. The shadow will move rapidly eastward and slightly to the north, leaving the continent near Currituck, South Carolina. At this point, the sun will be about four degrees above the horizon during the annular phase and the path of annularity will be approximately ninety miles wide.

The solar eclipse of May 30, 1984, is marked in Oppolzer's "Canon" as one which will be annular in some parts of its path and total in others. Schoch's elements indicate that this eclipse will just miss totality. The path of annularity will enter the United States near New Orleans and leave it near Georgetown, Delaware. At these points, the path will be approximately 13 and 9 miles wide, respectively, (subject to considerable uncertainty) and the annular phase will last only a few seconds. Near

New Orleans, the altitude of the sun will be about 62° during the annular phase while near Georgetown it will be approximately 73°.

The eclipse of January 4, 1992, will not be seen in the annular phase in this country. According to Schoch's elements, the path of annularity will end at sunset about fifteen miles off the Pacific coast near San Diego.

The path of annularity of the eclipse of May 10, 1994, crosses the United States from El Paso, Texas, to a point near Rockland, Maine. The altitude of the eclipsed sun will be about 49° and 58°, respectively, at these points. It will be seen on the meridian from a point in Lake Erie north of Cleveland, Ohio. The path of annularity will be about 130 miles wide in this country.

The paths of the seven eclipses seen in the annular phase in the United States are shown on the accompanying map. No attempt has been made to show the relative widths of the various paths.

REFERENCES

[1] "Die Neubearbeitung der Syzygientafeln von Oppolzer," C. Schoch, *Mitteilungen des Astr. Rechen-Institut*, **2**, No. 2, 1928.

[2] "A Test of the Accuracy of Oppolzer's Eclipse Predictions," Isabel M. Lewis, *Am. Astron. Soc. Publ.*, **7**, 92-93, February, 1932.

[3] "Total Solar Eclipses in the United States between 1933 A.D. and 2000 A.D.," C. H. Smiley, *Pop. Astr.*, **40**, 526-527, November, 1932.

LADD OBSERVATORY, PROVIDENCE, RHODE ISLAND, JUNE 27, 1940

Behavior of Nonradiating Particles in the Vicinity of a Radiating Body

By RONALD L. IVES

INTRODUCTION

Several of the speculations concerning the origin of the solar and other systems require the existence, at least during the time of formation of the system, of a resisting medium of some sort. The mechanics of the disappearance of all, or a large part, of this medium has not been very clearly described. Most of the attempts have used a gravitational approach. A somewhat different explanation, based on the opposing effects of gravitational attraction and radiational repulsion, is here presented in an elementary, and perhaps oversimplified, form. It is not expected that this brief discussion will lead directly to the solution of any of the numerous cosmogonic problems, but it is hoped that interest in these problems will be re-excited, and research stimulated, by this slightly different approach.

SIMPLE CASE

In a hypothetical space, containing only a radiating body and a perfectly absorbing one, the force, F_g, tending to draw the two bodies to-

gether, is:

$$F_g = K_g(Mm/S^2) \tag{1}$$

Where: K_g is a gravitational constant
M is the mass of the radiator
m is the mass of the receptor
S is the distance between radiator and receptor.

The force, F_r, tending to increase the distance between radiator and receptor, is:

$$F_r = K_r(A/S^2) \tag{2}$$

Where: K_r is a radiational constant
A is the area of the receptor in a plane normal to the direction of radiation.

Where $F_g = F_r$, the separation of the bodies will not be affected by either gravitational or radiational forces. This balanced condition may be expressed:

$$\frac{K_g(Mm/S^2)}{K_r(A/S^2)} = 1 \tag{3}$$

or, simplified:

$$Mm/A = C \tag{4}$$

Where C is the constant K_r/K_g and the net force between radiator and receptor will be attractive, zero, or repulsive as Mm/A is greater than, equal to, or less than C.

Imperfections of the Receptor

Should the receptor not be a perfect absorber, the outward force F_r, would not have the value indicated by equation (2), but may be expressed:

$$F_r = K_r(TA/S^2) \tag{5}$$

Where T is a compound correction factor whose value depends on the behavior of the specific particle to the radiation in question.

The condition of no net force between radiator and receptor is now given by the equation:

$$(Mm/TA) = C \tag{6}$$

and the net force between the two bodies is attractive, zero, or repulsive as Mm/TA is greater than, equal to, or less than C.

The correction constant T accounts for reflection, refraction, and diffraction, all of which are affected by the size, composition, and structure of the particle, which, under actual conditions, need not, and probably would not, be a theoretically perfect "black body." As the size of the particle decreases, the effects of reflection and refraction diminish, while those of diffraction become relatively more important.

Application to "Regimented" Space

In a "regimented" space, containing a radiating body and a large number of imperfectly absorbing particles, but having not more than one particle along any radius of the radiator, no matter how far it may be extended, certain of the particles may have properties such that Mm/TA

is greater than C. These will be drawn toward the radiator, and, in the course of time, space will be stripped of such bodies. In a "regimented" space where such particles exist, they will be those for which m/TA is largest.

Other particles may have properties such that $Mm/TA = C$. These, being neither attracted to, nor repelled from, the radiator, will retain their original positions relative to the radiator indefinitely, only a change in their properties, or in the radiation, being capable of altering their position, unless some "outside" influence acts upon them.

Still other particles may have properties such that Mm/TA is less than C. These will be repelled from the radiator, and in the course of time the space near the radiator will be freed of them. Far out in space, however, and still receding from the radiator, these "exiled" particles will be present. In a "regimented" space where such particles exist, they will be those in which m/TA is smallest.

In this hypothetical "regimented" space, originally occupied by a radiator and numerous particles having various properties, the gravitational and radiational forces will sort them into three classes:

1. *Attracted particles.* These, drawn inward by gravitation, will constantly decrease in number.

2. *Neutral particles.* These, neither attracted nor repelled, will behave much as if the radiator were absent.

3. *Exile particles.* These, driven away from the radiator, will remain constant in number, but their distance from the radiator will continually increase.

It should be noted that this classification is only valid in a hypothetical "regimented" space, where radiation is truly constant, where the particles are not mutually attracted by gravitation, mutually repelled by the pressure of reradiated energy, or influenced by electrostatic and magnetic forces, and where no "outside" influences are at work.

Adaptation to Chaotic Space

Chaotic space, containing a radiator having approximately the properties of a star, with numerous imperfectly-absorbing particles, having assorted properties, in its astronomical vicinity, presents a more complicated problem than the "regimented" space just considered. In this hypothetical chaotic space, the particles are, or can be, in motion, and hence may collide or shade one another. The mutual gravitational attractions of the absorbers, and the atmosphere of the radiator, introduce additional problems.

Direct collisions between perfectly elastic bodies involve only definite and calculable changes in velocity. Should the collisions be indirect, velocities will be less than calculated, as some energy may be used in producing axial spins. Should the colliding bodies not be perfectly elastic, some of their kinetic energy, at the time of a collision, is used up

in producing mechanical changes, or is converted into heat, which may be lost by radiation.

In chaotic space, as in regimented space, if a body is changed mechanically, its behavior toward existing forces is altered. If two colliding bodies weld together, or combine chemically, the mass of the new body resulting from their union will be the sum of the masses of the original bodies; but the cross-sectional area of the new body (under most conditions) will be considerably less than the sum of the areas of its components. Hence, the union of two particles will normally create a new particle, having a greater tendency to inward motion than either of its components. Unions of this type will lead to a reduction in the number of "exile" particles, and unpredictable changes in the number of neutral particles.

Where collision of particles leads to shattering, the sum of the cross-sectional areas of the fragments of a particle will greatly exceed that of the original, making the fragments more susceptible to radiational repulsion than was the parent particle. Shattering, therefore, will lead to an increase in the number of "exile" particles, a decrease in the number of attracted particles, and unpredictable changes in the number of neutral particles.

These considerations suggest that the neutral particles, to endure as such for any appreciable time, must not only be elastic, but also incapable of union with any other particle present in space. This seems to limit their composition to substances chemically inert under extant conditions.

Where the particles in space, regardless of their dimensions, are perfectly elastic, they behave much like oversized gas molecules, and their treatment as such, as suggested four decades ago by Sir George Darwin,[1] seems entirely reasonable.

In a chaotic space, containing a radiator and numerous particles of many sizes, all in motion, theory suggests a "Brownian" movement of the larger particles, resulting from the impacts of the smaller bodies.

As a result of the various motions of the particles in a chaotic space, caused by attractions, repulsions, and collisions, one particle may come between the radiator and another particle. The second particle will be shaded by the first, and the radiation pressure on it temporarily diminished. At the same time, the gravitational force on the second particle will be increased, the new inward force being the sum of the gravitational attractions of the radiator and the shading particle. This, coupled with reduction in radiation pressure, will give the shaded particle a greater tendency to inward motion than it previously possessed, and, as a result of mutual gravitational attraction, will give the shading particle a very slightly greater tendency to outward motion.

Thus, the temporary shading of one particle by another will change the motions of both particles, the change in motion of the shading particle being due to a slight reduction in effective gravity, that of the shaded particle resulting from a greater increase in effective gravity.

The net result of shading will be to cause the repulsive force due to radiation to decrease with distance at a rate somewhat greater than S^{-2}, while the attractive force of gravity will decrease at a rate slightly less than S^{-2}. This will lead to a zoning of the particles astronomically adjacent to the radiator, necessitating a re-classification. All particles having, in their initial positions, properties such that they will be attracted to the radiator, according to equation (6), will be atracted to it in this "zoned" space. All other particles, however, will, at some finite distance from the radiator, be in a position of balance, neither attracted to, nor repelled from, the radiator. At a lesser distance, these same particles will be "exiles"; at a greater, they will be attracted inward. These may be called zoned particles.

As the properties of matter, particularly in the form of molecules, do not change continuously, but in a series of steps, the distribution of matter in zoned space, after a time lapse sufficient for the establishment of equilibrium, would not be uniform. Surrounding the radiator would be a series of spherical shells, each composed of particles having the same m/TA relation, and each separated from the next by a zone of lesser density. The m/TA relation of the particles in the various shells will decrease from the radiator outward. Some interesting speculations concerning the formation of planetary systems, and bearing on planetary compositions, are suggested by this concept.

When shading, and the resultant zoning of particles in space, is considered, the effects of collisions need brief review. Collisions resulting in the union of particles will decrease the number of zoned particles; the particles formed by the union will seek an inner zone, and some may be attracted to the radiator, leading to a reduction in the mass of diffused material in space, and to an increase in the mass of the radiator. Collisions leading to the disruption of one or both of the colliding particles will increase the number of zoned particles, the fragments will seek an outer zone, and the total mass of diffused matter in space will be unchanged. Both union and disruption of particles will cause changes in the rate of attrition of radiational forces.

The mutual gravitational attractions of the particles in zoned space will tend to increase the number of collisions, an effect partially offset by the repulsive force of reradiated energy. Electrostatic and magnetic forces may also have important effects.

Radiation pressure will tend to strip the atmosphere of the radiator of all particles having properties such that Mm/TA is less than C, but this stripping would not be rapid, being inhibited by molecular collisions. The atmosphere of the radiator should serve as a reservoir of particles, having a "slow leak" toward the various zones in space.

The density of the radiator will tend to increase as a result of this "distilling off" of the less dense components of its atmosphere.

The mechanics of the atmosphere of a radiating body has been re-

viewed by T. C. Chamberlin,[2] who divides the atmosphere into three parts:

1. The common or collisional atmosphere.
2. The krenal atmosphere.
3. The orbital atmosphere.

From Chamberlin's considerations, it is apparent that a particle which would otherwise be attracted to the radiator could retain a position in space for some time if it assumed an orbit about the radiator, and that the life of this particle as a microsatellite would depend on the length of its "free path" around its orbit.

To Chamberlin's classification, another "atmosphere" should be added, on theoretical grounds. This:

4. The commutational atmosphere

is composed of commuting particles, whose behavior is analogous to that of water molecules in the terrestrial atmosphere. These commuting particles would not be long-lived, as collisions with other particles would tear away molecules of vapor.

Changes in Radiation

It should be apparent that a very slight change in the emission of the radiator in "regimented" space would cause profound changes in the behavior of the particles present. A slight decrease would cause all the neutral particles to fall toward the radiator, and would decrease the force tending to drive the exile particles to infinity. In time, a few of the denser exiles might be drawn inward, but the space in the immediate vicinity of the radiator would be vacant except for particles driven out of the radiator's atmosphere. A slight increase in radiation would likewise clear the vicinity of the radiator by exiling the neutral particles and accelerating the flight of those already exiled.

In contrast, a slight change in the emission of the radiator in zoned space would cause very little change in the state of the particles present, and would merely alter the radii of all the zones. A slight decrease in radiation would shrink all the zonal radii, and might cause the particles in the innermost zones to be attracted inward to the radiator. A slight increase in radiation would enlarge the zonal radii, and a new innermost zone might be created from particles expelled from the radiator's atmosphere.

Thus, it is apparent that, so far as relatively minor changes in radiation are concerned, the particles in zoned space are in a much less precarious condition than those in "regimented" space. Should, however, the radiation in zoned space vary greatly, such as by several orders of magnitude, the behavior of the particles would approach that in a "regimented" space where the change in radiation was much less.

Extension to Actual Conditions

In actual space, conditions differ considerably from those in the relatively simple hypothetical spaces just considered. About any single star, unaccompanied by satellites, and well within that star's spheres of gravitational and radiational control, the behavior of particles is substantially like that in zoned space. Farther away from the radiator under consideration, the gravitational and radiational influences of all other bodies in space become important—not necessarily at the same rate—and tend to alter the effective magnitudes of both the gravitational and radiational forces of the controlling body.

In addition to the gravitational and radiational forces under consideration, electrostatic and magnetic forces may be present and may have appreciable effects, which cannot be rigorously considered until their presence and magnitude is more definitely determined. The net effect of these forces may be considered as an alteration of effective gravity somewhat similar to that produced by radiation pressure. In the foregoing discussions, it has been assumed that all of the absorbing bodies under consideration are of molecular or larger dimensions.

The masses and radiations of all stars are not the same, nor is the mass-radiation ratio the same for every star. Hence, it is logical to assume that the spatial vicinities of different stars have different properties, and that the selective absorption of stellar light need not be the same for all parts of space.

Where two stars are astronomically adjacent, and the sphere of gravitational attraction of one overlaps the sphere of radiational repulsion of the other, a transfer of matter may take place, as was suggested, on purely gravitational grounds, some years ago by T. C. Chamberlin.[3]

Where a number of stars, or star clusters, are astronomical neighbors, the behavior of particles radiationally repelled from all of them is somewhat complex, and a general mathematical statement of their behavior, involving the solution of a problem of n bodies, is not possible.

About each member of a star community, there will be a zoning of particles according to their m/TA relation, but the zones, as a result of the force interactions existing in the community, will not be concentric with the dominating star. The eccentricities and distortions of the zones will increase as the distance from the dominating star, and hence the effectiveness of the controls of the other members of the community, increases.

These various actions and interactions may produce, in the spatial polyhedron at whose apices are the members of the star community, a spatial trap, into which particles having a definite range of m/TA relations are driven by the radiational repulsions of all members of the community, and from which they cannot escape because of these same repulsions, aided by the gravitational attractions of the various controlling

stars, and perhaps by the attractions of the other particles occupying this spatial limbo.

Should sufficient material having the right range of m/TA relations be available, a spatial cloud will eventually be produced. In it, the component particles should be in continual motion, as a result not only of their inherited velocities and mutual gravitational attractions but of collisions, and of the effects of shading, which causes temporary changes in the magnitude of the radiational forces acting on the individual particles. It seems reasonable to believe that some of the clouds of diffuse material in the heavens occupy spatial traps.

So long as these cosmic ishmaelites are perfectly elastic, and incapable of either chemical or mechanical union, the cloud will not integrate. As the amount of material in the cloud increases, the mean free paths of the trapped particles shorten, and the tendency toward union of the particles increases. In the interior of the cloud, because of the shading of the inner particles by the outer, an "energy trap" will tend to develop, leading to an increase in the temperature of the innermost particles, a trend favoring integration.

Eventually, provided conditions do not change, and adequate material is present, nuclei of condensation will be produced, or fortuitously introduced from "outside," and will grow by gravitational accretion. This growth, once it is well under way, should be quite rapid, and a new radiator, having at first some of the properties of a nova, might be produced as the potential energy of position of the particles forming the cloud is converted by infall to energy of impact, raising the temperature of the nucleus. Thus, a nova might be produced by the creation of a star, as well as by the explosion of one, the collision of two stars, or the friction resulting from the passage of a star through a cosmic cloud.

The fate of this newly-integrated body, too large to be appreciably affected by radiation pressure, and occupying a gravitationally unstable position, is problematical. It seems reasonable to believe that such a body would be attracted to one of the nearer and more massive members of the star community of which it forms a part, and would eventually collide with the attractor, or become satellite to it. This leaves the cosmic trap empty, but still able to collect diffuse material, having very nearly the same range of m/TA relations as before the creation of the new stellar body.

In this same star community, particles having an m/TA relation so small that they cannot be held either by a star or retained in the trap will be repelled outward and eventually come to rest in one of a series of botryoidally-shaped shells about the entire star community. Similar shells should also be present about binary and ternary systems.

In any planetary system, such as the solar system, the shells near the radiator will eventually be removed by the attraction of the planets, and those far out in the system, if any exist, will undergo continuous periodic disturbances as a result of planetary influences. The scavenger ac-

tion of planets is an important factor in their growth, as was pointed out a generation ago by Drs. T. C. Chamberlin and F. R. Moulton, joint authors of the well-known planetesimal hypothesis of the origin of the solar system.

Conclusions

The behavior of a particle under the influences of gravitation and radiation pressure, as here considered, using as bases only elementary physics, elementary astronomy, and the materials cited in the bibliography, suggests explanations for a number of astronomical phenomena, and hints at the existence of others, as yet unreported. According to the reasoning here outlined, the following conclusions, in general accord with data derived from observation, and with theory deduced from other sources, may be drawn:

1. In the astronomical vicinity of a radiator, particles will be sorted into zones, concentric with the radiator, and these zones will have radii primarily determined by the m/TA relations of the particles.

2. The distribution of particles in the space controlled by the radiator will not be either uniform or in accord with any simple law, for the properties of matter, particularly when present as molecules or quasi-molecules, do not change continuously, but by a series of steps.

3. Changes in radiation will have less effect on the position of a particle in zoned space (where conditions approximate those in actual space) than in the more orderly hypothetical "regimented" space.

4. Shading of one particle by another will lead to a change in the motion of each particle.

5. Collisions between particles will lead to changes in their motions, and may lead to changes in their numbers.

6. The atmosphere of the radiator will be stripped of certain particles by radiation pressure, and hence will replenish the space in its vicinity.

7. A commutational atmosphere, composed of particles that change state in transit, could exist, under certain conditions, in the near vicinity of a radiator.

8. When the mass-radiation ratios of two adjacent stars are not identical, a transfer of matter from one to the other may be expected, as suggested by Chamberlin.

9. In actual space, containing stars having various properties, surrounded by shells of diffuse material also having various properties, the selective absorption of stellar light should not be exactly the same for all parts of space.

10. Spatial traps may be produced within star communities. These may eventually contain clouds of diffuse matter, which may in time condense into solid bodies. These, able to escape from the trap under gravitational influences, may become companions to older stars in the community.

11. Particles having m/TA relations so small that they cannot be held in zones about individual members of a star community, nor trapped between them, will be repelled outward and into one of a series of shells of diffuse material surrounding the entire community.

12. The number of shells about the radiator of a planetary system should be very small, and those present should be beyond the orbit of the outermost planet.

BIBLIOGRAPHY

[1] Darwin, G. H., "On the mechanical conditions of a swarm of meteorites, and on theories of cosmogony," *Phil. Trans.* London, 1888, 1-29.

[2] Chamberlin, T. C., "Two solar families," Chicago, 1928, 41-42.

[3] Chamberlin, T. C., "The origin of the earth," Chicago, 1916, 22, (included bibliography pertinent).

Moving the Dearborn Observatory

By OLIVER JUSTIN LEE

Due to rearrangement of buildings on the north campus of Northwestern University in Evanston to make room for the main building of the Northwestern Technological Institute, the Dearborn Observatory was moved during the summer of 1939 a distance of about 664 feet south and east.

So far as the writer knows this is the first case on record of moving so large an observatory, as a unit, to a new location. The engineering problems involved and the completely satisfactory results attained have interested many people, some of whom have suggested that a short description of the operation should be published. This note complies with that request.

The observatory building measures eighty feet north and south, seventy feet east and west across the meridian circle, and forty-nine feet east and west at the north end. The circular wall under the dome lies inside the building for about two-thirds of its perimeter. Including the conical, hollow, brick pier the weight of the heavy stone building was estimated to be around 2500 tons, very unsymmetrically distributed.

Nothing was removed from the building before moving except the large lenses in the telescopes, and such plates and records as we needed to continue our work in temporary quarters in the Engineering Building. The last plate taken at the old site was exposed on June 18, 1939, and the first at the new location on November 13, 1939.

Six-foot trenches were made around the building exposing the concrete foundation. Sections about a yard wide were cut from the base, permitting the insertion of many 16-inch I-beams just under the sills of the ground floor. The ends projecting outside rested upon long square timbers having 14-inch cross section. Similar wood timbers were inserted under the building to distribute the weight. Under the timbers were

placed hundreds of jack screws which rested upon pilings built up by laying short 4-inch by 6-inch timbers criss cross.

The piers of the refractor and meridian circle were cut below the ground floor and smaller beams were inserted which in turn rested upon the large beams.

Everything was now ready for lifting the building about three feet to make room for the tracks which supported the building while in transit. Twenty-six men were stationed at the jack screws. When the foreman blew his whistle every man inserted his bar successively into the jacks assigned to him and gave the screw a quarter turn, corresponding to a lift of one-eighth of an inch. Each man operated twenty-thirty jacks. When these had been turned up twelve inches everyone turned to "fleeting up" the jacks, that is, resetting them on more piling for the next trick.

Piling for seven tracks were then laid, one for each of the long timbers which ran all the length of the building in the direction of moving. Long steel shoes were placed under these timbers, between which and the tracks were inserted hundreds of three-inch solid steel rollers about thirty inches long, which rested upon short lengths of steel rails staggered four or five wide and laid on the track piling.

Now came the rigging of long steel cables passing through single steel pulleys back and forth thirty times between the rear ends of the seven long timbers and large trees or "dead men" up ahead. The two outside free ends of the cables were attached to double-cone capstans each operated by a team of horses hitched to a twelve-foot sweep. Two inside free ends were wound by a powerful winch on a caterpillar tractor.

The dramatic moment had arrived. Teams, drivers, winch man, roller tenders, foremen, astronomers, and officials of the University stood at attention. The moving boss blew his whistle; slowly the cables and other gear tightened, adjusted itself to the load, and in a few seconds the building gave a gentle lurch. The Dearborn Observatory was on its way to its new site.

The building had been moved about two-thirds of its length when a small crack appeared about ten feet from the north end, as if the north wall could not quite keep up with the procession. A halt was called. Conference of architects and engineers yielded the decision to brace the structure before proceeding. Three one and one-half-inch steel rods were put through the building from north to south walls, anchored at outside walls, and snubbed up tight with turnbuckles. The experts also decided to eliminate possible spreading of the walls of the main building by the heavy slate roof. Second story walls and floors were torn up and a series of two by twelve planks were fastened near the lower ends of the rafters. After this was done the process of moving, laying tracks in front and taking them up behind proceeded until the building was over its new foundations. Most of the time was spent in hauling the material for the tracks, which were constructed on a level from old to new sites,

and irregularities in the terrain were leveled off with scrapers or filled with blocking as necessary. The building arrived at its new site six feet above datum. When moving was done it was at the rate of twenty inches per minute. That is, the building was in motion about seven hours to cover the 664 feet—the rest of the three months was used for building the tracks.

We anticipated trouble with the east side of the meridian circle room because the shutters and end doors almost cut the room in two. An old crack caused by settling many years ago opened very slightly, and that was all. Incidentally it should be mentioned that before the building was disturbed on its old foundation large scale photographs were made of all outside walls upon which were marked all discernible cracks.

The conical brick pier which supports the eighteen and one-half inch refractor does not touch the three floors through which it passes. The clearance averages about half an inch. So delicately and firmly was this pier and the telescope upon it moved that at no time from start to finish did it touch any of the floors. Its one hundred twenty-five tons of weight was balanced upon beams under the first floor.

When the building arrived at its new site the foundations were well set and ready. By chance the new site selected straddles the filled-in bed of an ancient creek known to Northwestern people of a generation or more ago as the Rubicon. In making the foundations it was decided to lay the spread footings on a very tough, resistant blue clay which tests showed to be very suitable. For example, the blunt end of a steel rod having a cross section area of around 0.4 inch was thrust into this wet blue clay with a jerk. Thereafter the weight of one man drove the rod an inch or two deeper. When the full weight of a second man was added the rod sank a half inch more, and stopped. This corresponds to a pressure of around fifty tons to the square foot. The actual weight of the building averages less than three tons per square foot of footing area, which gives a 15-20 fold margin of safety. Another test with several tons of weight confirmed the order of firmness of the blue clay which we got at first. We were fully satisfied.

Due to the sloping contours of the clay stratum in the old Rubicon we placed our footings, four feet wide, at varying depths below the general surface, ranging from five to thirteen feet.

After the building had been placed correctly over the basement walls the jacks were removed differentially so as to close the few minor cracks that had developed. The rest of the operations may be passed without comment.

Less than a square foot of plaster in the aggregate fell. The workmen in quite a short time put the building back into much better shape than it was before we moved.

The observatory now stands forty feet west from the edge of the twenty-foot shore bluff of Lake Michigan, sixty feet north of the Garrett Institute Dormitory, and one hundred feet east of the north end of

Garrett Institute.

The center of motion of the refractor is forty-three feet above the ground so that the Garrett buildings are approximately on our horizon south and west. In consequence they do not obstruct our view of the sky. Neither will the gigantic main building of Northwestern Technological Institute interfere.

The only Dearborn research which is at all affected by the change in location is our Longitude Campaign of 1933-34. Before operations began we set up a net of angles and distances around the observatory into which we could fit the new position of the center of motion of the meridian circle, our datum for latitude and longitude.

The correction to our old position is $-0^s.186$ in longitude, and $-6''.221$ in latitude. These give the present position as follows:

Latitude North 42° 3′ 27″.2;
Longitude $5^h\ 50^m\ 41^s.843$ West of Greenwich.

These changes have been reported to the Nautical Almanac Office in Washington, and will appear in the *Ephemeris* for 1942 and thereafter.

This account of moving the Dearborn Observatory may be closed by relating a detail of human interest.

Before moving began, the R. C. Wieboldt Corporation, which holds the general contract for these changes on our north campus and for the construction of the Technology building, employed a surveying concern to insure that the observatory would be oriented to the cardinal points *just as it was* in the old location.

When the walls had been cast we made several determinations of azimuth by the sun and Polaris, and consistently found that the north end of the foundation was about two inches too far east, an angle difference of 7′. The matter was of no consequence, because as is well known telescope and meridian circle have to be adjusted differentially on their piers to the meridian, anyhow. We mentioned the difference to an engineer from the downtown office of the Corporation. He answered that that office would have to pass upon the question whether to orient according to their surveys or ours, and that they took considerable pride in accurate following of instructions. We dismissed the thing from our minds.

After the building was fully in place upon its new foundation we again made repeated determinations of the azimuth of the same west wall and found that these scattered about equally north end west, north end east, of the actual wall. In other words, to the accuracy we worked, the building was correctly oriented to the cardinal points.

One day we commented to this effect to the chief of the movers, Mr. Albert Crowe, and to a practical engineer on the job, Mr. Bert Simondson. They dryly remarked, "Well, we wanted to put the building where you wanted it, gentlemen, and we are glad we succeeded."

DECEMBER 2, 1940

Solar and Sidereal Time

By H. BOYD BRYDON

Confusion sometimes exists regarding the difference between solar and sidereal time. The confusion perhaps results from a conflict of ideas between the two meanings of the word "day."

1. "A day is the interval of time between two consecutive returns of the sun to the meridian." This is a solar day.

2. "A day is the interval of time taken by the earth to make one complete revolution on its axis." Put in the form of definition 1, it is "the interval of time between two consecutive returns of the same star to the meridian." This is a sidereal day.

As the sun is within the earth's orbit and the star is far outside it, these two time intervals are not the same. The solar day is longer than the sidereal day.

The explanation of this difference is not a complicated one, but verbal explanations, however formulated, lack the power which an experiment has in fixing in the mind the truths of nature. Readers are therefore urged to try for themselves the simple experiment described below.

1. On a sheet of paper draw a fairly large circle, the size of a dinner plate, for example, to represent the orbit of the earth. Mark the approximate center of the circle and call it the "Sun."

2. Draw a straight line from the "sun" to the right hand edge of the paper and assume that far out beyond the end of this line there is a star or other reference point such as that point on the celestial sphere known as "the first point of Aries" or the "Vernal Equinox."

3. Cut from cardboard a small disc $1\frac{1}{2}$ to 2 inches in diameter to represent the earth. Draw on it a diameter and mark its ends with the head and tail of an arrow.

4. With a pin through the center of the disc secure it temporarily to the spot where the straight line from the sun crosses the earth's orbit, with the nock of the arrow towards the "sun" and its point towards the distant star. Mark this position "start." It is the position of the real earth at noon on March 22.

Clearly now if the "earth" be rotated on its axis, the pin, every time the direction of the arrow is parallel to the straight line from the "sun" the "earth" will have completed a rotation, no matter where it is or may be moving in its orbit. By definition 2 above then, it will each time have completed a sidereal day.

Clearly also by definition 1, every time the nock of the arrow points to the "sun" the earth will have completed a solar day.

The experiment consists in moving the "earth" eastward round the sun and at the same time rotating it on its axis also eastward (that is,

counter clockwise looking from the north or pin's head end) and noting, first, the number of complete rotations made; and second, the number of times the nock of the arrow points to the sun during the process. The particular number of rotations made is not important. When the earth has completed its journey round its orbit and is back again at the starting point it will be found in every case that the number of times the nock of the arrow has pointed to the "sun" will be one less than the number of complete rotations the "earth" has made on its axis.

The experiment shows why solar and sidereal days are not the same. It shows that a solar day is longer than a sidereal day because, after completing a rotation, the earth, due to its motion in its orbit, has to turn a little farther round each day before the nock of the arrow again points to the sun.

The experiment shows also that (omitting fractions of days in both cases) while there are 365 solar days in a year there are 366 sidereal days in a year. This means that a sidereal time-clock runs faster than a mean solar time clock, since it records a greater number of days in the same time interval.

How much does star time gain on sun time? If the number of solar hours in a year, 8760, be divided by the number of sidereal days in a year, 366, the length of a sidereal day is found to be shorter than a solar day by nearly four minutes. That is, star time gains on sun time by nearly four minutes a day.

As the positions of the stars in the sky at a given instant depend upon sidereal time, not on solar time, it follows that a star which is on a given meridian at a certain instant today will have passed on to the west of it by four minutes at the same time tomorrow and by eight minutes on the day after tomorrow. In the course of a month this difference in time amounts to ($30 \times 4 = 120$) two solar hours or one-twelfth of a solar day. Hence, in the course of a month there is a westward drift of the stars, with respect to the sun, by one-twelfth of a circle or 30°. As the earth rotates on its axis once in 24 hours, the extent of this westward drift of the stars during a month can be seen by noting the change in their positions during a period of two hours on any clear night.

The result of this drift is that as each month goes by (excepting those stars which are so close to the pole that in our latitude they do not set) the stars in one-sixth of the visible half of the sky sink below the western horizon while stars in another one-sixth which were below the eastern horizon come into view. A further result, as our experiment shows, is that those constellations which today are behind the sun and lost in the glare of the daylight, in due season become visible to us again as the motion of the earth in its orbit apparently removes the sun from its temporary position between us and them.

Here we must make a correction. We speak of the stars rising and setting. Actually they do nothing of the sort. They only seem to do so. It is the earth which moves, not the stars. Like the philosophers of old,

however, we are so accustomed to accepting the earth as motionless, except for an occasional earthquake, that we forget that in reality we are being carried round on a rapidly rotating globe and that with us goes the plane of our horizon which extends from us in all directions like a great flat disc at whose boundary earth and sky meet.

The stars appear to rise because, as we are carried round by the earth, the eastern edge of this plane continually moves downward uncovering stars which are there all the while, and appear to set because its western edge, tilting upward, hides the western stars from our view.

That we may know what stars will be visible on any date the corresponding sidereal time must be known. The sidereal day begins at a given place, that is, the sidereal time is 0^h at the instant when the vernal equinox is on the meridian. As the vernal equinox, like the stars, crosses the meridian two hours earlier every succeeding month, there is a simple rule by which the sidereal time can be found to within a few minutes for any time of any day in the year.

The rule is this: Add together two hours for each month elapsed since noon on March 22 last, four minutes for each day since the last 22nd day of a month, the hours and minutes since noon on the day selected and ten seconds for each of those hours. If the sum is greater than twenty-four hours, subtract twenty-four hours from it. The result is the sidereal time required. For example:

Wanted sidereal time at $1^h\ 50^m$ A.M. on February 6.

		h	m
March 22 to January 22 = 10 months.	10×2 hrs. =	20	00
January 22 noon to February 5 noon = 14 days.	10×4 min. =		56
Noon February 5 to $1^h\ 50^m$ A.M. February 6	=	13	50
14×10 sec. = 140 sec.	=		2
Sum		34	48
Subtract		24	00
Sidereal time required		10	48
Sidereal Time by Nautical Almanac		10	52

Having found in this simple way the sidereal time corresponding to a given instant we can note for any civil time, by reference to the right ascension marked on the upper and lower borders of star maps, which stars will be close to our meridian, which will be to the west of it and which to the east of it, and their distances from it in terms of time or "hour-angle" by the fundamental formula for the observer:

Hour-angle = sidereal time — right ascension.

When right ascension equals sidereal time it is clear from this formula that hour angle is zero. That is, the star is on the meridian. If the star's right ascension is less than the sidereal time at the moment, the star has passed to the west of the meridian; if it is greater, the star is still to the east of the meridian, "the" meridian meant being in all cases the meridian which passes through the north pole and the zenith of the

place of observation.

The "right ascension" of a star then is seen to be the same as the sidereal time when that star arrives at the meridian. It may be likened to the time given in a railway time-table at which a certain train is due to arrive at our station.

While not directly a matter of solar and sidereal time, the apparent contradiction that, although the moon makes a complete rotation on its axis during every circuit of its orbit, it always keeps the same side towards the earth can also be cleared up by an experiment with our working model.

Remembering, as was learned from our first experiment, that in its journey round its orbit a body, *as seen from inside that orbit,* appears to make one less rotation on its axis than actually it does, let us suppose that the circle, instead of representing the orbit of the earth around the sun, is the orbit of the moon round the earth. Then we mark its center the "earth" instead of the "sun" and what was the "earth" now becomes the "moon." If now the moon be moved eastward round its orbit we shall find that, in order to keep the nock of the arrow pointing towards the earth, the moon, *as seen from outside its orbit* (which is where we stand to count the rotations of a wheel for example), must also make one complete turn eastward on its axis during the journey.

It is important to observe that these statements are true only because the directions of revolution and rotation of the actual bodies take place as described. If, for instance, the moon turned westward on its axis or did not rotate at all while moving eastward round its orbit the same side could not remain facing the earth. How such different directions of motion would affect the length of the day in the case of the earth and the sun can be seen by trying the experiment.

Conversion of Standard Time into Sidereal Time

By J. O. HASSLER

The short method of finding local sidereal time from Standard Time without the use of local Mean Time here given is especially useful for late evening observers in the United States. Let D be the difference in Standard Time between Greenwich and the observer's station and suppose D is greater than the remaining time until midnight, a condition which is fulfilled after 7:00 P.M., E.S.T., after 6:00 P.M., C.S.T., etc. Let θ be the desired local sidereal time, G the sidereal time of Greenwich at 0^h U.T. of the *next day* (given in the *Nautical Almanac*), I the interval of time elapsed since 0^h U.T. of the next day, g the gain in sidereal over mean time for this interval, and λ the longitude of the observer. The obvious formula is

$$\theta = G + I + g - \lambda.$$

For example, at 8:30 P.M. in longitude $6^h\,29^m\,46^s$ (University of Oklahoma Observatory) on September 1, 1940, it is necessary to add $2^h\,30^m\,25^s$, the interval since 6:00 o'clock plus gain in sidereal time $(I + g)$ to $22^h\,43^m\,58^s$, the *Nautical Almanac* entry for G on September 2, and subtract the longitude. It can all be done in a few seconds.

UNIVERSITY OF OKLAHOMA, JANUARY 12, 1941.

Observations of Variable Stars — Some Problems

By WALTER SCOTT HOUSTON

The numerous observations of variable stars made each year by the more experienced workers are always a source of wonder to the novice. Beginners find it difficult to understand how the experienced members of the A.A.V.S.O. annually report from 1000 to more than 5000 estimates. Indeed, when the newcomer spends several hours without finding a single field, his astonishment at the work of the other men becomes very great. Many of these novices are well satisfied with six or seven estimates in an evening, yet the experienced observer may make from fifty to one hundred observations in about the same time.

This much-discussed problem is one which the serious amateur must face when he determines to make his efforts most fruitful; and although the technique of efficient observing cannot be considered as completely formulated, this collection of opinions from various active AAVSO members may suggest interesting trends and perhaps may be useful.

Published studies on this topic are divided into two groups: one type concerns accuracy of observation, and includes "An Introduction to the Study of Variable Stars" by Furness, "Researches in Stellar Photometry" by Parkhurst, and the *Circular* No. 1 published by the AAVSO. The second group considers the efficiency of observation and is much smaller. Mr. David Rosebrugh has published notes in the *Journal of the Royal Astronomical Society of Canada;* the *Texas Observers Bulletin* has scattered material; the various publications of the Milwaukee Astronomical Society and its related organizations do the same. Perhaps the only serious study is the one made by Mr. Leo Scanlon and printed in *Variable Comments* for July, 1934.

By the use of a questionnaire, Mr. Scanlon obtained valuable information on observing practices from the most successful observers of variable stars. His study indicated, briefly:

1. Successful observers did not use elaborate equipment.
2. Successful observers had an observing program.
3. Successful observers used either circles or finders once the field was found.
4. Successful observers could usually make the estimation in less than one minute.

This paper hopes to extend the material in Mr. Scanlon's article and in the AAVSO *Circular*. It will omit all information fully discussed in these two places; and because there exist adequate discussions of accuracy in observing, this paper will consider only the problem of efficiency.

The telescope itself is the first problem—how may the amateur obtain one, and in what manner shall it be equipped? The lack of funds is not a valid excuse, for in this country today there is no reason that an astronomer should not have the small telescope best suited to his needs. Spare-time labor for a few months will suffice to grind a mirror, and so numerous are the amateur telescope makers, so complete are the volumes "Amateur Telescope Making" and "Amateur Telescope Making—Advanced," both of them by Ingalls, that one may usually obtain experienced advice without difficulty. This is especially true in the larger cities where local clubs such as the Texas Observers and the Milwaukee Astronomical Society stand ready to assist the serious beginner.

If lens-grinding seems impractical, a little searching will oftentimes uncover a mirror which is for sale at a fair price. Six-inch mirrors have been sold for as little as $5.00, a ten-inch mirror may often be had for $25.00, and $50.00 will purchase an excellent professional six-inch. Of course the buyer must be prepared to test his mirror before purchase—and this applies to the small semi-professional lenses as well as to the purely amateur products. Often mirrors offered for sale are so badly figured that a return to fine grinding is necessary to correct them. The testing is easily within the powers of anyone and it should not be shirked as it is an interesting task.[1]

Telescopes of the reflector type, especially those of home manufacture, are often equipped with mountings and fittings that are more fantastic and elaborate than they are useful. The better practice, perhaps, is to buy only the mirror and make the mounting to suit one's own needs and specifications.

The variable star observer must not scorn the reflector. Perhaps it is more difficult to adjust, but outweighing this is the fact that the reflector is more comfortable to use. Its shorter *f*-ratio makes for larger fields at lower powers, and it costs far less. If it is equipped with an aluminized mirror, it will need but little repair over long intervals of time. Although older texts imply the opposite, (an impression dating back to the days of speculum metal mirrors) a reflector has about the same magnitude limits as a refractor of the same size. In practical work the difference, if there be any, is only a tenth or two of a magnitude. This is an important fact where money is limited, for the sum needed to get a refractor which will reach 13th magnitude will buy a reflector

[1] While this paper will consider reflectors in the main because of their cheapness, the amateur must not overlook his chances of getting a refractor. There are a good many excellent refractors stowed away in barns and attics which may be had for very small sums. The writer knows of several instances of this—in one case $25 bought a Brashear 4-inch complete with tripod and equatorial mounting.

which will reach 15th magnitude or fainter. Indeed, in sizes above six inches, refractors are too dear for any but the professional organizations; whereas, amateur reflectors of six, ten, and even fifteen inches are common.[2]

The reflector has been familiar to the American amateur since about 1925 when the *Scientific American* began publishing articles on lens-grinding, and the merits of this type are but recently appreciated in this country. In England, the smaller reflector has been the standard amateur instrument for a hundred years, and in the hands of their observers it has accomplished valuable original research in planetary study, celestial photography, and the observation of variable stars.

Once the mirror or lens is acquired, either by purchase or by home construction, the next task is to devise a mounting which shall be simple, trouble free, and adequate to the type of observation contemplated—in this case the study of variable stars. Chromium plating, polished brass, and good looking machining are non-essential. Actually only two qualities are important.

First, the mounting must be massive; vibration cannot be tolerated for it makes it impossible to see the faintest stars in the field. Many novices design their mountings "strong" enough to support the tube. This is a wrong way of viewing the problem; the proper approach is to design for "rigidity"—to design so that all vibration, all whip and play, is eliminated. This requires a mounting far heavier than if mere support were the only factor. Four-inch iron pipe has been found too flexible for a five-inch telescope! Really, a brick or concrete pier is the only effective support. The axis members must be surprisingly large and heavy. 1¼-inch cold rolled shafting is none too big for a six-inch, and a ten-inch telescope can well use two-inch shafts.

Second, the instrument must have a reliable method of finding stellar fields—either circles in good adjustment, or an adequate finder, also in adjustment. The most discouraging part of variable star work is inability to locate fields, and, because of this, the tyro should be certain that his method of locating them is reliable beyond all manner of error.

If circles are to be used an equatorial mounting is necessary,[3] but it need not be expensive. Heavy, cold-rolled shafting, turning in hard maple pillow blocks and lubricated with floor-wax or graphite, functions well. The circles should be large—about fifteen inches in diameter, and

[2] The writer suggests the 6-inch reflector as the perfect instrument for variable stars. It can be built by a beginner; it needs no complicated mounting, and may be portable; it is small enough so that no stepladder is needed, and all parts can be reached without much motion. Such an instrument will reach from thirteenth to fourteenth magnitude, reach 200 fields a month, and make 500-1000 observations a month without undue labor.

[3] Circles, or rather a modification of them, may be attached to even the alt-azimuth form of mounting. Mr. D. F. Brocchi has cleverly worked out one method of doing this, but it requires rather more skill in construction than the average amateur possesses.

should be graduated only to degrees. Nothing more precise than that is of use to a variable star observer, and it may be noted here that the professional astronomer rarely uses the finely divided circles on his large equatorial. A clock, if it be added, should drive the hour circle and not the polar axis.

It will surprise some professional astronomers to learn that the equatorial mounting is not at all essential to easy and efficient observing, but this is true. If the amateur depends upon his finder to locate fields he will have little need for the rather cumbersome equatorial. Especially is this true when the telescope is large and the ocular difficult of access in certain positions. Several very active observers use alt-azimuth mountings with complete success and satisfaction. All that is needed is a good finder and a good atlas, such as the AAVSO Atlas or the Webb Atlas. Inasmuch as the finder is the important element of this system, it should have excellent lenses and be mounted for use rather than for appearance. The usual way of mounting a finder is to place it so close to the main tube that one cannot look through the finder without much effort. Perhaps it is no great error to say that 80% of finders on amateur telescopes are rendered useless by their attachment to the main tube.

But getting a mirror and a mounting is an easy task compared to the troubles of locating one's first stellar field. This procedure is adequately described in the *Circular* No. 1 of the AAVSO and will not be repeated here. After the trials of locating one's first dozen fields, the beginner will understand that the problem of efficiency depends mainly upon this operation.

Scanlon's study indicated that experienced observers, once the field had been found, took less than a minute to make the estimation. Observers average less than a dozen fields an hour, and it is obvious that any technique that will reduce "finding time" and related activity will increase the number of estimates. Curiously enough a good three-quarters of the time is spent, not in actual estimation, but in looking for charts, moving the stepladder and dome, sweeping for the field, selecting the fields to be observed, and similar operations.

Proper program planning is one method of turning this waste time into actual observing minutes, and all the evidence shows that a planned program is essential. Selection of charts should not be done during precious clear evenings. Rainy nights, off afternoons and the like are the times to arrange the charts in observing order. This too is the time for noting fields which remain unobserved and for fitting them into the schedule where moonlight will not interfere.

The charts may be filed in folders by designation number or in a loose-leaf book. If one has a dome to turn this method is advantageous. It means, however, that the telescope must be turned through long arcs of declination, and to the observer who uses a stepladder this is most inconvenient.

Better suited to the reflector is the chart file by constellation, especial-

ly if the instrument sits uncovered in an open yard,[4] and since most amateurs own this type of housing the method may be elaborated. It is a slight modification of the one used by members of the Milwaukee Astronomical Society.

By this plan all fields in a constellation are observed before moving to another area. This system seems, in actual practice, to better prevent "overlooked" fields than does the first mentioned method. Since most constellations are small, moving of the tube and ladder are minimized, for often six to ten fields may be reached without the observer moving from the eyepiece. For a few extended constellations, such as Hya, Her, etc., the charts are sub-grouped inside the folder.

Bi-monthly the AAVSO lists the expected brightness of some 400-500 variables, and these data are used to sort the charts in each folder. All of the variables bright enough to be seen by the instrument are placed in front of the folder; the others are put in the back with a clip about them. As the fields are observed they are turned over with their white backs lying up. Thus at any time a glance will show which fields in an area are yet unobserved. This method has advantages over the usual check list.[5]

As soon as all the fields in a constellation are observed the area is shaded in on the penny sky map published by Toronto Observatory. This map thus gives a quick picture of the progress of the work for that month—a valuable aid to future planning.

The usual routine on a typical evening is to look at the Toronto map before supper and select from the file the folders for several constellatons yet unobserved or only partly observed. Once at the telescope one need only attend to those charts that lie face up. This is as easy a method of selection as any the author has tried and it makes for speed and accuracy.

In addition to this type of planning, the program must also fit the lunar month, for, with the exception of the irregulars, most variables should be estimated only in a dark sky. Indeed the fainter minima cannot be reached if there is much moonlight. One plan is to commence the observing month after full moon as soon as the early evening sky becomes dark. Start on the western horizon and work eastward. This keeps the program far behind the moon and assures dark skies all month long.

This type of organization has other, perhaps less recognized, advantages for it insures that the regular long period variables are observed

[4] A dome is an obstacle to rapid work and at the same time very useful and handy as a protection. There seems to be no adequate solution to the problem except perhaps the Burnham dome. But the author has never seen one used by a variable star observer except J. W. Simpson's.

[5] The Milwaukee Astronomical Society, where many coöperating observers use the same set of instruments, have a similar system. However, used charts are thrown into a discard box so no one will inadvertently re-observe those fields that month.

only once a month, and it thus eliminates much of the over-observing which at times appears on the records. It encourages the observer to hunt down the hard-to-find fields which the casual person overlooks, so that they are consequently under-observed. Lastly, the locating of all manner of fields sharpens the general talent of the observer and contributes to his general efficiency.

This is the procedure for the ordinary long-period variables. Special folders are provided for the U Gem type, R CrB type, nebular variables, novae, etc., which need daily attention. Because these special fields are so often observed, the amateur learns to find them with a speed which astonishes professional astronomers. These important fields are usually estimated at the beginning of the evening lest unexpected clouds put them beyond reach, and the remaining hours are spent on the more unimportant stars.

A few hardy and fortunate observers, anxious to put their time to the best possible use, retire early and rise after midnight to work in the early morning sky. This is most commendable as ten estimates here are usually worth fifty in the early evening heavens.

Program is a major element of efficient observing; ease of operation of the telescope is another. If the circles do not read correctly, if the polar axis must be aligned anew each evening, if opening the dome or unwrapping the instrument is a small ceremony in itself, then valuable time is lost and enthusiasm evaporates. Simplicity and reliability should be the Holy Grail of amateurs. Electric clamps, clock drives, ball bearings are of little value in variable star work with the rapid shifting from field to field that characterizes such research. A more practical activity is to spend twenty minutes and adjust the counterweights so that the instrument does not move no matter where it is pointed. Observing like this, without clamps, is convenient and rapid.

The ocular too must be easy of access. Refractors on low tripods waste time; it is easier to climb a low step than to squat on the ground. Here the conveniently pointing eyepiece of the reflector demonstrates its worth. If a "bent finder," one with a diagonal-prism eyepiece, is used the main eyepiece and finder ocular may be mounted parallel and but an inch or so apart. The convenience of this arrangement is obvious, and although the smaller field is mirror-imaged it is not unhandy with bright objects, and the troubles of faint star fields are quickly overcome.[6]

The "finder versus circles" argument is endless; proponents of each side are firm that their method is the best. In the circle camp may be found almost all of the professional astronomers and the textbooks; the finder enthusiasts are likely to be amateurs, and they include some of the country's best and most active workers. It must be granted that a novice works best with circles. However, circles (especially the types with

[6] A non-reversing diagonal eyepiece is possible and simple to construct—although it was not invented until D. F. Brocchi approached the problem a few years ago. The Texas Observers can furnish full information.

minute graduations) take a certain time to set, and as the observer becomes proficient no great gain in setting time may be expected.

While the finder, on the other hand, is a trial to the beginner, it is also a boon to the owner of the portable instrument and to the man who cannot afford an elaborate polar axis. Setting speed increases with practice in this latter method, and soon it is faster and more certain than circles. In regions of the sky where the variables lie close together such as in Del, Cyg, Lyr, CMi, one may go from field to field without leaving the eyepiece—a feat difficult with circles.

One observer has written that he gave up reflectors because the field rotates at various hour angles. Unfortunately many people hold this fact as a condemnation of the instrument, although the exact opposite is true. It is actually easier to judge field rotation with a reflector than with the refractor. For if the former be equatorially mounted the field never rotates with respect to the axis of the tube. Once the chart orientation is found, all charts may be held against the tube at the same angle and will correspond to the field in the ocular.

Of course the alt-azimuth does rotate the field with respect to the tube, but even this is not the bogy that some writers would make it. The author began using this form about two years ago and found that it was no task at all to understand the skewing of the field in various parts of the sky, and it soon became as easy to use as any other type of mounting.[7] A small amount of experimentation made upon familiar fields in various portions of the sky will show just what orientation to use, and, indeed, if one works by constellation the change is so small from field to field as to be entirely non-distracting.

With the finder method one must have a dependable atlas. The variables are plotted on the atlas, and by then setting the finder upon the proper field the star may be located. Even observatories which use circles are likely to employ finder charts traced from the B.D. (*Bonn Durchmusterung*) to insure identification of the star. To be effective this atlas must "look" like the sky. Most modern charts are not well drawn to meet this requirement mostly because they are not consistent about the faint stars they plot. Perhaps the only naked-eye atlas that is properly constructed is that of D. F. Brocchi which is published in blueprint form by the AAVSO. These charts show all stars to magnitude 6.05 and no others. The discs change diameter every tenth of a magnitude and the plates bear an excellent resemblance to the heavens. The blue-print paper is tough and stands dew, wind, and muddy boots equally well, whereas printed charts soak up to a rather pulpy mess. The Brocchi atlas has removable sheets, making it convenient to use at the telescope.

The comments upon charts would not be complete without a note on the charts that contain stars to fainter than naked-eye magnitudes. Of

[7] Except at the zenith where the rotation is confusing.

these the B.D. charts which include most stars to 9.1 are unobtainable although photographic copies are at times available. The Beyer-Graff series, charts to 9.5 with nebulae and clusters to 13.0, are on a smaller scale than the B.D. and have been quite common in this country, although the war has possibly stopped further importation. Lately, Mr. Harold Webb has produced a set of maps on the Beyer-Graff scale, and differing in that the names and magnitudes of the brighter stars are indicated, which may prove to be the best set yet available to the American amateur.

Finally, after telescope and observing program has been decided upon, there comes the task of finding a site for the observatory. Much has been written upon this problem, but one point may need more emphasis.

Most amateurs dream of a nice, white, little observatory set on some country hilltop where no trees mar the sweep of the horizon and no smoke obscures the clarity of the air. Some fortunate persons obtain such sites, but for the individual who is concerned with making the best use of his time and equipment such establishments are not suitable. The amount of observing done usually bears a direct relation to the distance from the back door to the telescope. The shorter this distance, the easier it is to uncover the telescope, the more estimates will be made. A rural observatory is a fine possession—if one has two telescopes and can keep the better instrument in the backyard. Then when there is a free half-hour (too little time to pack up and drive ten miles to the "observatory"), one can go out in the garden and get ten observations. Ten such evenings a month yield a respectable number of estimates. These small clusters of data swell monthly totals, and their continuity greatly increases the ultimate scientific value of all variable star observation.

Planet Notes for March, 1941

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. Apparent positions of the sun for March 1 and March 31, respectively, are: $\alpha = 22^h\,46^m.2$, $\delta = -7°\,48'.7$; $\alpha = 0^h\,36^m.3$, $\delta = +3°\,55'.1$. The sun will be moving in a northeasterly direction through the constellations Aquarius and Pisces during March. Spring begins March 21, $0^h\,21^m$, which is the instant the sun reaches the vernal equinox.

Moon. Phenomena of the moon will occur as follows:

		h	m
First Quarter	March 6	7	43
Full Moon	13	11	47
Last Quarter	20	2	51
New Moon	27	20	14

		h
Apogee	March 2	21
Perigee	14	22
Apogee	30	10

Eclipses. A partial eclipse of the moon will occur on March 13, the beginning of which will be visible generally in most of North America. Further details will be found under "Planetary Phenomena in 1941" in the January, 1941, issue of POPULAR ASTRONOMY.

An annular eclipse of the sun will occur on March 27, 1941, invisible from the United States. The path of the annular eclipse extends from a point east of New Zealand in a northeasterly direction over the Pacific Ocean, then easterly to longitude 56° 43′ W, latitude 12° 43′ S, in South America. Again, further details may be had by reference to the article mentioned above.

Mercury. Mercury will reach greatest elongation March 25, 15^h, and will, for a few days around this time, be visible as a morning star, though low and inconspicuous in the southeastern sky.

Venus. Venus is approaching superior conjunction with the sun and will be inconspicuous as a morning star during March. Data of interest to observers are listed in POPULAR ASTRONOMY, **49**, 30, 1941.

Mars. Mars, during March, may be found as a morning star, rising some three hours before the sun. However, the southerly declination of the planet will result in its being rather inconspicuous. The planet's angular diameter during the month is about 6″. Its distance from the earth varies from 157 million miles on March 1 to 134 million miles on April 1.

Jupiter. Jupiter will be an evening star during March, situated in the constellation Aries.

Saturn. Saturn, like Jupiter, is an evening star in the constellation Aries.

Uranus. Uranus is an evening object during March and will be situated in the constellation Taurus as illustrated by the chart in POPULAR ASTRONOMY, **49**, 34, 1941.

Neptune. Neptune reaches opposition on March 17. The position of the planet in the constellation Virgo is illustrated by a chart in POPULAR ASTRONOMY, **49**, 35, 1941.

Occultation Predictions

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1941		Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′				h m	m	m	°	h m	m	m	°
Mar.	3	147 B.Ari	5.8	23 37.1	−1.5	−0.8	82	0 56.6	−1.1	−0.8	254
	5	α Tau	1.1	17 28.6	−0.3	+1.6	83	18 35.5	−0.7	+1.8	250
	7	130 Tau	5.5	5 41.7	−0.3	−0.2	51	6 22.5	+0.6	−2.3	318
	9	68 Gem	5.1	5 19.4	+0.3	−4.0	165	5 50.5	−1.4	+0.6	223
	10	84 B.Cnc	6.4	7 43.4	+0.7	−3.5	171	8 6.8	−0.6	+0.4	221
	11	222 B.Cnc	6.3	0 17.7	−1.5	+1.1	90	1 30.6	−1.6	−0.7	303
	12	43 Leo	6.3	5 55.5	−0.8	−2.5	151	6 50.9	−1.5	−0.8	256
	16	2 Lib	6.3	11 6.2	..	..	33	11 27.5	..	..	355
	20	64 B.Sgr	6.1	8 25.6	..	..	26	8 55.6	..	..	340
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′											
Mar.	3	ξ Ari	5.5	3 7.3	0.0	−2.9	128	3 48.3	−0.3	+1.0	210
	3	147 B.Ari	5.8	23 1.5	−2.2	0.0	82	0 31.4	−1.8	+0.2	245
	5	α Tau	1.1	17 24.0	+0.2	+1.6	73	18 23.1	−0.2	+1.4	262
	7	130 Tau	5.5	5 34.9	−0.6	−0.9	77	6 34.4	+0.1	−1.9	294
	10	29 Cnc	5.9	4 8.8	−2.4	+0.7	68	5 9.5	−0.9	−3.0	329
	10	222 B.Cnc	6.3	23 55.0	−0.8	+1.0	98	1 3.7	−1.2	+0.4	288
	16	2 Lib	6.3	10 33.4	−2.0	+0.6	53	11 17.7	−1.1	−2.9	341
	20	64 B.Sgr	6.1	7 50.5	−0.9	+2.2	61	8 45.8	−0.6	+0.1	309
	20	17 H.³Sgr	6.4	9 46.2	..	..	25	10 15.6	..	..	341
	20	*Y* Sgr	5.4-6.2	10 57.8	−1.9	+0.8	85	12 22.3	−2.1	0.0	274
	24	96 B.Aqr	6.5	10 45.7	−0.5	+1.9	69	11 53.5	−0.9	+1.4	264
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′											
Mar.	6	318 B.Tau	5.7	6 19.8	−0.6	−1.7	107	7 24.2	−0.4	−0.8	256
	7	130 Tau	5.5	5 9.9	−1.4	−1.9	115	6 24.8	−1.4	−0.6	255
	8	26 Gem	5.1	6 8.6	−2.3	+1.2	50	6 58.1	−0.3	−3.8	331
	10	29 Cnc	5.9	3 4.3	−1.8	+0.4	101	4 27.8	−2.1	−0.4	285
	10	222 B.Cnc	6.3	23 42.0	+0.1	+0.9	97	0 38.2	−0.3	+0.7	282
	16	2 Lib	6.3	9 26.8	−1.9	+0.2	100	10 43.9	−1.7	−1.0	305
	16	4 G.Lib	6.5	10 18.1	−2.9	+1.6	61	11 8.5	−1.0	−2.7	343
	20	*Y* Sgr	5.4-6.2	10 18.8	−0.6	+0.3	118	11 24.0	−1.5	+1.5	252
	21	ρ Sgr	4.0	12 27.0	−1.4	+0.7	103	13 45.4	−2.0	+1.2	250

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

The Pulsation Theory for Long-Period Variables: It has been felt for a long time that the different forms of light curves presented by long-period variables might have their origin in the ease or difficulty encountered by the propagation of waves from the interior of the stars through the various atmospheric layers to the outside. It has also been suggested that the pulsation theory, found to explain in many ways the cause of variation in Cepheids, might also be applied, with modifications of course, to long-period variables.

A real step in this direction appears to have been made by R. M. Scott in his recent paper, with the above title, presented at the December, 1940, meeting of the American Astronomical Society. He finds that the diameter-curve for Mira, *o* Ceti,

derived from a study of the emission line velocities in this star, when compared with the corresponding diameter-curve computed from Pettit's and Nicholson's temperature and radiometric magnitudes, shows a very good agreement as to phase and shape. He suggests that the source of the emission lines lies in the same region of the star's envelope as the radiometric photosphere. By fitting the amplitudes of the two curves, he derived directly the parallaxes and minimum diameter as 0".020 and 3.1×10^{13} cm, respectively. The bolometric absolute magnitude is therefore $-3^{M}.45$. Four other long-period variables were similarly investigated by Scott and were found to have substantially the same absolute magnitude.

With these fundamental data available for Mira Ceti, Dr. M. Schwarzschild's pulsation equation was then used and the solution presented a good agreement with the bolometric light curve. The solution showed that the following conditions held:

(1) That the density gradient through the outer layers of the star must be very small.

(2) That the amplitude of the oscillation remains nearly constant throughout the envelope.

(3) That the velocity of propagation of the wave in the outer envelope is small.

(4) That a part of the star is probably in convective, rather than radiative, equilibrium, which indicates that giant currents must be operating within the star.

Heretofore theoretical studies of the pulsation problem in long-period variables have been mainly from absorption line velocities, and it remained for Scott to investigate the problem from the angle of the observed emission line velocities. He appears to have found the proper working key to the solution.

The Variable Star TV Andromedae: The variable star TV Andromedae, 225342, has been on the A.A.V.S.O. observing list for the past 2000 days, about five and a half years, and although the observed range is only slightly more than a magnitude, a very satisfactory record of its variations has been secured.

The star was discovered by Madame Ceraski in 1908 and the *Geschichte und Literatur Catalogue* classified it as a long-period variable with a range in magnitude between 8.9 and 11.1, and a period of 63.4 days—evidently derived by Luizet —but with marked irregularities.

That there are irregularities present, especially in the earlier observations by Enebo and Beyer, there is little doubt, but the recent observations do not show strong evidence of irregularity. Some observers have classified the variable as of the RV Tauri type, doubtless because of the observed irregularities, but a re-examination of the early observations does not confirm the RV Tauri-type of variation.

The variable departed radically from its usual form of variation in 1910 and 1911, according to Enebo's observations, and again in 1934, according to Beyer, but such demarkations were not present in the observations of the *Astronomish Selskab* and the A.A.V.S.O. from 1925 to 1940. To be sure the light curve does not appear to be as smooth as is usual for long-period variables, but this may be due in part to the difficulty encountered in observing a very red star with such a small range in variation.

The period of 63.4 days is certainly not confirmed. The period of 114.4 days appears to satisfy the observations except during the years when the star was varying in a peculiar manner. The variation during these years recalls to mind the peculiar light changes found for R Aquarii.

Curiously enough, Dr. Gerasimovič found no trace of regular variation when he studied the star on Harvard photographs in 1937, but he did note the large difference in color index at maximum light.

A detailed study of the recent A.A.V.S.O. material indicates that the star has most of the attributes of a long-period variable, with a mean range in variation between magnitudes 9.4 and 10.5. The extreme range is, of course, somewhat larger, perhaps between the ninth and the eleventh magnitudes, and there appear to be no signs of the forms of variation noted in RV Tauri-type variables. The mean period of 114.4 days, with an average deviation of three days, well satisfies the observed maxima and minima from July, 1935, to the present time, and appears also to satisfy the earlier dates derived from the observations of Enebo, Beyer, and the *Astronomish Selskab*.

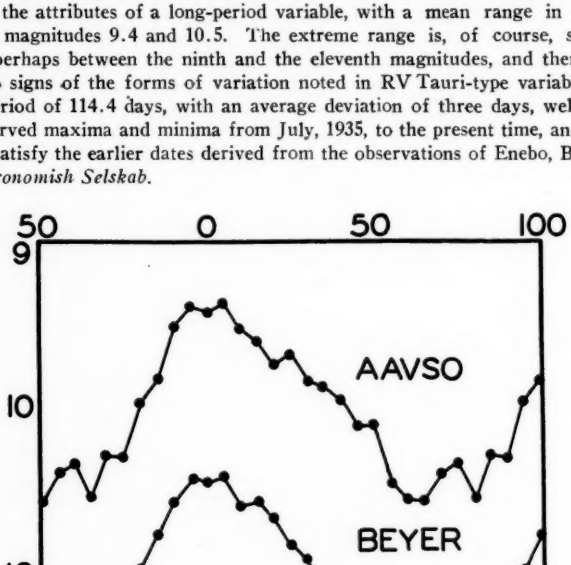


FIGURE 1
MEAN LIGHT CURVE OF TV ANDROMEDAE

Mean light curves have been derived from the A.A.V.S.O. observations, and from those of Beyer made in the years 1923 to 1929, and these are shown in the figure; the upper curve is that of the A.A.V.S.O., the lower curve that of Beyer, omitting the observations of 1924. Little difference is found to exist in the shape of the two curves, and they are typical of a long-period variable of small range, short period, and with an M4 spectrum. The star might well be observed photometrically over several cycles in order to ascertain whether or not the irregularities noted in earlier dates reappear.

Light Curve of SS Cygni in 1940: Nearly 900 observations of the variable SS Cygni were contributed to the headquarters of the A.A.V.S.O. in the year 1940. Seven maxima were observed and apparently none was missed in spite of the fact that few estimates were made during March and April when the star was unfavorably placed for observation. From May 1 to the end of the year, there were only 22 nights on which observations were not reported. The observations are contained in Table I under daily means, together with the number of estimates

included in each mean value. These values are illustrated in Figure 2.

TABLE I

DAILY MEANS OF SS CYGNI, 1940

242	—0—	—1—	—2—	—3—	—4—	—5—	—6—	—7—	—8—	—9—
9630	8 9.56	7 10.19	4 10.95	6 11.30	7 11.30	5 11.60	3 11.93	3 11.70	4 11.72	2 11.95
9640	5 11.74	2 11.60	2 11.80	2 11.45	.....	2 11.95	.....	1 11.7	1 11.9	.....
9650	1 12.0	1 12.1	.....	.....	2 11.90	3 11.87	7 11.83	2 11.75	3 11.87	2 11.80
9660	2 11.95	.....	3 11.80	3 11.53	3 11.63	1 12.0	.....	.....	1 11.2	1 11.6
9670	1 11.8	4 11.35	1 11.5	.....	1 11.5	2 10.60	2 9.60	2 9.30	.....	2 8.70
9680	.....	2 8.50	1 8.70	2 8.50	.....	.....	2 8.50	.....	.....	.....
9690	.....	1 10.0	.....	.....	.....	.....	.....	.....	.....	1 11.4
9700	.....	.....	.....	.....	.....	1 11.4	.....	.....	.....	.....
9710	.....	1 11.8	.....	.....	.....	.....	.....	.....	.....	.....
9720	.....	1 11.9	1 11.6	.....	.....	.....	1 11.5	1 11.7	1 11.7	.....
9730	.....	.....	.....	4 11.68	.....	.....	.....	.....	.....	.....
9740	3 8.70	.....	.....	.....	.....	.....	2 9.65	.....	3 10.37	1 10.2
9750	1 10.8	.....	1 11.8	2 11.60	.....	1 12.0	.....	1 11.9	.....	4 11.95
9760	1 12.0	.....	2 12.00	.....	1 11.9	1 12.0	.....	1 12.0	.....	2 12.00
9770	1 11.1	1 12.0	.....	.....	2 11.60	.....	.....	1 11.9	1 12.0	.....
9780	1 12.0	1 11.7	4 11.98	2 11.95	2 11.90	1 11.9	2 11.95	3 11.93	1 12.0	1 12.1
9790	1 12.0	1 12.0	.....	1 11.5	2 12.00	.....	4 12.00	2 11.85	.....	1 11.9
9800	4 8.62	6 8.55	5 8.50	2 8.70	2 8.45	2 9.05	4 9.33	2 9.30	4 10.12	5 10.16
9810	10 11.14	4 11.32	8 11.44	6 11.77	2 11.65	4 11.65	11 11.77	8 11.67	4 11.82	3 11.87
9820	1 11.3	.....	1 12.0	5 11.88	8 11.78	4 11.90	1 11.7	1 12.0	1 11.7	.....
9830	2 11.60	3 11.83	1 11.7	2 11.90	5 11.84	4 11.80	.....	3 11.67	.....	5 11.78
9840	2 11.85	2 11.85	6 11.83	5 11.76	6 11.60	4 11.78	5 11.76	7 11.60	4 11.80	5 11.30
9850	7 11.30	4 10.95	1 8.5	9 8.45	5 8.50	3 8.50	7 8.63	4 8.60	3 8.73	3 8.73
9860	3 8.77	3 8.70	13 8.70	8 8.95	5 9.30	8 9.62	5 10.44	2 10.75	4 10.90	1 11.8
9870	2 11.85	2 11.45	5 11.76	3 11.37	3 11.50	2 11.55	8 11.50	8 11.56	8 11.62	4 11.42
9880	1 11.3	4 11.60	.....	2 11.75	1 11.7	2 11.70	2 11.80	3 11.90	1 11.9	1 11.7
9890	1 11.7	3 11.57	5 11.66	5 11.80	6 11.55	4 11.52	1 11.7	4 11.45	10 11.43	.....
9900	7 11.57	4 11.52	5 11.36	5 11.48	3 11.67	2 11.30	4 11.52	6 11.27	4 10.32	3 9.63
9910	1 10.0	5 9.48	9 9.47	5 9.18	4 8.90	6 9.05	5 9.34	3 9.53	3 9.83	3 10.27
9920	1 10.7	2 11.20	2 11.55	1 12.1	5 11.84	9 11.89	6 11.90	3 11.93	3 12.03	6 11.78
9930	6 12.00	3 11.93	2 11.85	1 12.0	1 11.9	2 11.85	4 11.90	2 11.85	2 11.75	1 11.8
9940	2 12.05	2 11.90	1 11.8	2 11.95	2 11.95	.....	1 11.7	1 12.0	2 11.70	1 11.7
9950	2 11.90	2 11.80	2 11.55	2 11.75	4 11.85	1 11.9	4 11.85	1 11.9	4 11.85	3 11.63
9960	2 12.05	1 11.8	6 11.90	2 11.65	3 11.70	5 11.70	2 11.80	4 11.82	1 11.9	1 11.3
9970	3 11.50	2 11.55	2 11.60	3 11.83	1 11.7	1 11.8	1 11.8	.....	.....	2 11.75
9980	1 9.2	3 8.90	3 8.67	1 8.7	2 8.75	2 8.40	2 8.40	5 8.88	1 9.3	3 8.90
9990	1 8.7	2 9.05	.....	1 9.7	1 10.3	2 10.75	1 11.0	.....	1 11.6	1 11.9

Three of the observed maxima were of the rapidly rising type, A3, A5, and A8; two were of the moderately rising type, B2 and B3; and two were of the slowly rising type, C3 and C5. These designations of types are based on those derived by the Recorder in the study made of this variable in 1934.

Table II lists observational data for each maximum for three phases—Magn.

TABLE II

OBSERVED MAXIMA, 1940

Type	J.D. 10.0 I	Diff.	J.D. Max.	Diff.	J.D. 10.0 D	Diff.
		d		d		d
B2	29625	51	29627	57	29631	60
C5	29676	64	29684	57	29691	57
A3	29740	60	29741	62	29748	61
A5	29800	52	29803	56	29809	57
B3	29852	58	29859	56	29866	53
C3	29910	70	29915	71	29919	75
A8	29980	..	29986	..	29994	..

10.0 I, Maximum, Magn. 10.0 D—with their respective first differences. The mean cycle during the year was 51.3 days, slightly longer than that derived from the mean of all cycles observed from 1896 to 1933, which was 50.4 days.

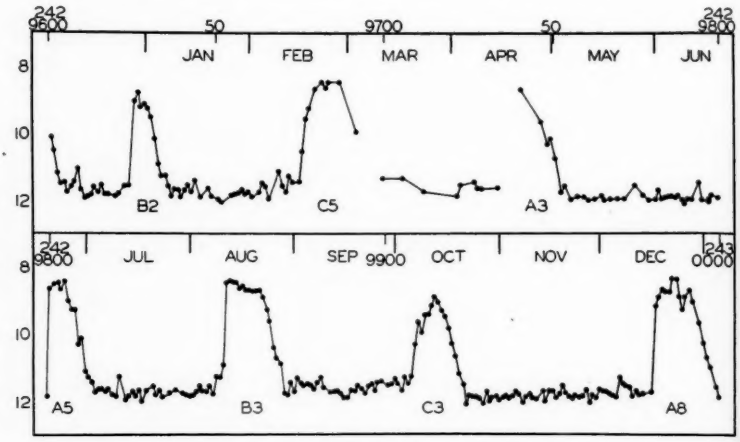


FIGURE 2
LIGHT CURVE OF SS CYGNI, 1940

Observers and Observations received during December, 1940:

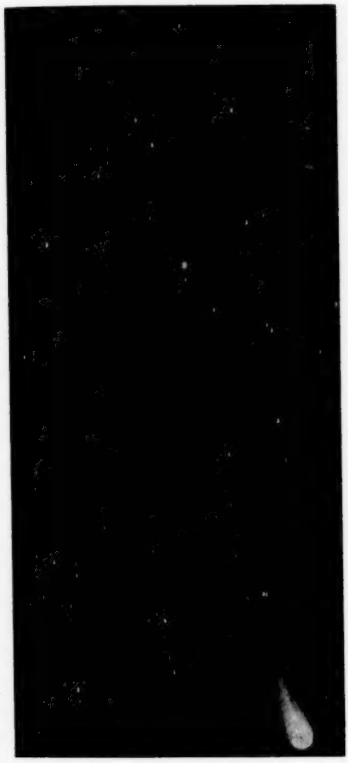
Observer	Var.	Obs.	Observer	Var.	Obs.
Albrecht	13	18	deKock	58	240
Baldwin	41	41	Livingston	35	53
Ball, J.	43	52	Lovinus	14	14
Blunck	6	9	Mason	9	18
Bouton	43	54	Maupomé	46	48
Buckstaff	10	18	McKeon	1	10
Cilley	54	155	Milnes	1	2
Cousins	43	150	Moore	3	3
Dafter, Mrs.	5	25	Parker	13	13
Diedrich	16	18	Parks	25	43
Escalante	66	98	Peltier	86	148
Ferguson	7	9	Prinslow	7	7
Fernald	91	112	Purdy	8	8
Friton	2	4	Rosebrugh	13	59
Griffin	7	7	deRoy	15	60
Halbach	11	11	Ryder	13	13
Harris	12	12	Saxon	34	48
Hartmann	157	219	Schoenke	12	22
Hiett	10	26	Sill	51	51
Holt	127	298	Smith, F. P.	5	5
Howarth	10	10	Stahr, Miss	5	5
Jones	43	87	Topham	43	43
Kanda	2	6	Webb	26	26
Kearons, Mrs.	72	136	Yamasaki	20	20
Kelly	16	23			
Knott	4	4	50	Totals	2531

January 14, 1941.

Comet Notes

By G. VAN BIESBROECK

The short-lived climax of CUNNINGHAM'S COMET has passed as far as the northern observers are concerned. The general public has been disappointed in the expectation of a brilliant cometary display, both on account of the generally cloudy weather conditions and of the failure of the comet to reach as great an intensity as the prediction indicated. Nevertheless, those who have been fortunate in catching a view of the comet low in the western evening sky have been aware that it has developed into a fine object and that under better geometric conditions of visibility it would have made a magnificent display. In spite of the difficulties with the conditions of visibility a great many photographic records have been obtained in various localities showing that from a length of a few degrees early in December the tail had grown to an extent of some 15 or 20 degrees at the turn of the year. The complex nature of the tail is hard to describe. The figure herewith is from a 6-minute exposure at the 24-inch reflector on the evening of January 2. It illustrates that the tail consists of a bundle of streamers, the main one of which stretches in a nearly straight line diagonally across the field, breaking up into lateral branches at several points. Near the head there are a number of shorter individual streamers which spread into a wide dissymetrical fan. It will take a comparative study of the records taken at various stations to get an idea of the rapid changes that must have taken place in the tail. At any particular place the visibility was of too short duration for bringing out such changes in the course of one night. Total brightness was estimated by the writer as $3^{M}.5$ on the evening of January 2 and $3^{M}.4$ on January 4. When a last naked-eye glimpse was obtained on January 5 the moon interfered and the low altitude precluded any reliable estimate. The comet is now in conjunction with the sun but will emerge bright for southern observers at the end of this month.



COMET CUNNINGHAM
1941, Jan. 2, $23^{h}\ 57^{m}$ U.T.
(Exposure 6 minutes at 24-inch Yerkes reflector.)

The object remained close to the position predicted by the discoverer which

means that deviations from a parabolic orbit must be small and that the period of revolution around the sun will prove to run into centuries.

With the disappearance of COMET CUNNINGHAM no other known comets are in reach of ordinary telescopes. COMET OKABAYASI was recorded here on January 3 as a tiny nebulosity of magnitude 17 quite close to the position indicated by an improved orbit computed by A. D. Maxwell. It will not be observable much longer.

This year the following periodic comets are due to return to perihelion:

Comet	Perihelion Date
Tempel (2)	1941 Feb. 10
Encke	April 18
Schwassmann-Wachmann 1930 VI	April 16
Schwassmann-Wachmann 1925 II	September 1

The conditions of visibility are too unfavorable for the first object. Encke's comet should become visible as an evening object before very long. The following ephemeris by the late A. C. D. Crommelin indicates the position (*British Astronomical Association Handbook*, 1941):

1941	α	δ	—Distance from— sun	earth
	h m s	° ′		
Feb. 3	23 42 9	+ 5 55	1.47	1.96
7	48 22	6 31		
11	23 54 57	7 9		
15	0 1 55	7 50	1.30	1.93
19	9 17	8 34		
23	17 4	9 19		
27	25 20	10 7	1.12	1.83
Mar. 3	34 6	10 58		
7	43 27	11 50		
11	0 53 25	12 44	0.93	1.68
15	1 4 6	13 40		
19	15 34	14 37		
23	28 11	15 53	0.72	1.49
27	41 9	16 29		
Mar. 31	1 55 22	17 19		
Apr. 4	2 10 26	+18 1	0.50	1.23

It will, however, remain a faint object.

The two other expected comets also will hardly come in reach of ordinary telescopes.

Williams Bay, Wisconsin, January 13, 1941.

Notes from Amateurs

An Organization of Amateurs

Due to the world conditions, the number of amateurs able to carry on much needed observations of a planetary nature has been seriously cut down. In order that these important observations may not be seriously cut off also, an attempt is being made to organize the amateurs not already associated with the few societies already bent in that direction, into a group of sincerely interested observers who are willing to devote their talent and instruments to the science we would dislike to see suffer because of a dearth of observers. It is important that a program be started soon because of the training of the eye and hand necessary before results

of real value may be secured. With such a group of well-trained observers the favorable approach of Mars in 1941 may be well studied and results of value secured. The beginning observer is also welcomed, and a suitable program of interest will be outlined that will give the training necessary for a successful planetary observer.

If you feel that you would be interested in this group I will be very glad to hear from you, regarding your instruments, favorableness of locality, and your experience. It is hoped that this plea will be answered by as many amateurs as possible.

FRANK VAUGHN, JR.

532 Polk Blvd., Des Moines, Iowa.

The Herschel Astronomical Club of Fall River, Massachusetts

The annual Christmas meeting of the Herschel Astronomical Club of Fall River was held on December 26.

The principal talk of the evening, "Leander McCormick Observatory," was presented by R. Gardner Reed, a student-observer at that institution. Mr. Reed described the 26-inch objective lens in the large refractor, reputed by many to be Alvan Clark's best.

The work of guiding the telescope during a plate exposure was explained: eloquent testimony to the inaccuracies in the most perfect driving mechanisms.

As the primary function of the McCormick Observatory is the determination of parallaxes, this particular type of observation was described in interesting detail.

At the next meeting, Reverend William M. Kearons will describe his work on solar photography.

FRANK J. KELLY, *Secretary.*

278 Centre Street, Fall River, Massachusetts.

METEORS AND METEORITES

Contributions of the Society for Research on Meteorites

Edited by **FREDERICK C. LEONARD,**
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Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

Meteorite Craters and the Hypothesis of the Existence of Contraterrene Meteorites

By LINCOLN LA PAZ,
Department of Mathematics, The Ohio State University, Columbus

ABSTRACT

Craters presenting unmistakable evidence of an impact origin have been excluded from the category of meteorite craters because no meteoritic materials have been found in or near them. The origin of certain silica-glass deposits (closely resembling the glasses produced by fusion of siliceous materials in the intense heat incident to meteoritic impact with the surface of the Earth) is regarded as a mys-

tery, because meteorites have not been found associated with these deposits. Attention is called in this communication to the possibility of the existence of *contraterrene meteorites* (defined in the paper), which would be just as capable of producing meteorite craters and silica-glass as are ordinary meteorites, but of which no trace would remain after collision with the Earth.

In spite of the impressive array of evidence which L. Kulik,[1] I. Astapowitsch,[2] and others have presented to prove that falling meteorites produced the funnels investigated in the Podkamennaya Tunguska, Siberia, region, L. J. Spencer[3] and other high authorities have expressed doubt that the Siberian craters were created actually by meteoritic impact, because no meteorites have been found in or around them, although repeated search has been made. The absence of material definitely recognizable as meteoritic has sufficed to cast doubt upon the authenticity of several other "meteorite craters," notably the famous rock-basin of Köfels;[4] Lake Bosumtwi in Ashanti;[5] the Nördlinger Ries and Steinheim Basins;[6] the Pretoria Salt Pan;[7] and the so-called "Carolina Bays."[8]

While it is true that in some of the cases just cited, traces of nickel or nickeliferous iron have been found in fusion products (silica-glass, *Köfelsite*) in or near the craters, it is true also that igneous rocks like those whence these fusion products were derived very generally carry appreciable amounts of nickeliferous compounds. Thus, according to F. Heide,[9] the average amount of NiO present in igneous rocks considerably exceeds the percentage of this compound found by spectroscopic analysis in Köfelsite. Under these circumstances, it is perhaps not surprising that craters which exhibit many or most of the features characteristic of known meteorite craters (including, possibly, alignment on known meteorite-crater loci[10]) are accepted as being genuinely meteoritic only when, as in the case of the Estonian pits,[11] macroscopic masses of meteoritic iron are finally found associated with them.

An equally anomalous situation exists in connection with certain remarkable deposits of silica-glass. The classical example is that of Darwin Glass (*Queenstownite*), most of which, as Spencer has pointed out, closely resembles the silica-glass found in abundance about the genuine meteorite craters at Wabar, Arabia. Although this fact has been known for a long time and although a similar silica-glass has been produced indubitably by meteoritic impact, at the neighboring Henbury craters in Australia, nevertheless there are those who classify Queenstownite as ordinary obsidian, merely because no meteoritic masses have been found associated with it. Even Spencer has only recently committed himself on the Queenstownite problem in the following statement:[12] ". . . we can safely conclude that these 'tektites' [Darwin Glass] at least were produced by the fusion of siliceous terrestrial materials in the intense heat developed when a large iron meteorite struck the Earth's surface. No traces of meteorite craters or meteoritic iron have been found (nor specially searched for) at the locality . . ."

Since, as Spencer has pointed out also, the silica-glass found in the Libyan Desert "closely resembles" small, clear, greenish-yellow fragments of Darwin Glass, one might expect him to attribute the Libyan deposit, likewise, to meteoritic impact, in spite of the fact that, as in the Tasmanian case, no meteorites have been found associated with the glass. Such is not the case, however, for in a recent publication on the subject, Spencer writes:[13] "A special look-out was kept for meteorites in the desert, but none was found. Any depressions (such as clay pans) were examined in the hopes that they might prove to be meteorite craters. Publication of the above notes has been delayed now for five years, in the forlorn hope

that some clue might turn up to help solve the mystery of the silica-glass of the Libyan Desert."

The mineralogist is not alone in the belief that every genuine meteorite crater must have meteorites associated with it; *e.g.*, Kulik, convinced though he was, by his personal investigations, of the impact-origin of the Podkamennaya Tunguska funnels, nevertheless felt under compulsion to explain his failure to find meteorites belonging to the fall of 1908 June 30. As a result, we find him and his supporters advancing the suggestions that the Siberian meteorites were completely vaporized or flew off into space again.

It is the purpose of the present paper to call attention to a remarkable hypothesis which has recently been given serious attention by a number of prominent physicists and which, if well founded, affords an immediate explanation of how craters and silica-glass deposits may be created by falling meteorites, even though no fragments of the meteorites remain to be discovered.

The reader will recall that the "1940 edition" of the atom is conceived to consist of a positively-charged nucleus about which revolve one or more negatively-charged electrons. Because of a certain symmetry between positive and negative electric charges suggested by the Quantum theory of the electron, it has been conjectured by Dirac,[14] Gamow,[15] Rojansky,[16] Zwicky,[17] and others, that in free space, there may exist atoms of matter in which the rôles played by the positively- and negatively-charged particles are interchanged. Such atoms, in which the nuclei are charged negatively and in which the extra-nuclear members are positrons, are called *contraterrene atoms,* and matter built up of such atoms is termed *contraterrene matter,* to distinguish it from ordinary matter, which is called *terrene.* Spectroscopically, these two kinds of matter, according to Dirac and Rojansky, are indistinguishable.

From considerations of symmetry and from the known behavior of an electron and a positron at collision, it is inferred that when a contraterrene particle collides with a corresponding terrene particle, the two elements of matter are completely annihilated with the release of an extraordinarily large amount of radiant energy. Since ordinary atomic nuclei would attract contraterrene nuclei (just as electrons are known to attract positrons), it follows that the mutual annihilation of macroscopic masses of terrene and contraterrene matter brought into contact would proceed with explosive violence. Consequently, if there exist meteorites of contraterrene material, large enough to survive the dual wastage of ordinary ablation and superficial annihilation (occasioned by collision with terrene air-molecules) during passage through the atmosphere, the resulting impacts with the Earth would be followed by *explosive annihilation.* From a rough calculation made by Rojansky,[16] it can be inferred that an approximately cylindrical, contraterrene, iron meteorite, falling with its axis vertical, will survive transit through the atmosphere and collide with the Earth if, *e.g.,* its radius is 40 cm. and its altitude is 150 cm. In comparison with the dimensions of known iron meteorites, these dimensions are very moderate. If a contraterrene iron meteorite of a size comparable to those of the largest irons conjectured to have fallen should strike the Earth, an extremely powerful explosion would result, since, in addition to the large store of heat energy resulting from the transformation of the kinetic energy of motion of the meteoritic mass, a vast amount of energy would be liberated by its annihilation. In this manner, genuine meteorite craters of huge dimensions *might* be produced *without a trace* of the original meteoritic material remaining at the site of the explosion.

The descent of a large contraterrene meteorite into a sandy desert would result, not only in the formation of a meteorite-less meteorite crater, but also in the production of large quantities of silica-glass. The crater might soon be obliterated and destroyed by the marching sands, but the highly resistant silica-glass would endure to give rise in due time to such apparently inexplicable deposits as those found in Tasmania and the Libyan Desert.

REFERENCES

[1] Kulik, L., *C.S.R.M.*, **1**, No. 1, 29-34; No. 2, 15-20; No. 3, 59-62; *P. A.*, **43**, 499-504; **44**, 215-20; **45**, 559-62; 1935-37.
[2] Astapowitsch, I. S., *C.S.R.M.*, **2**, No. 3, 203-26; *P. A.*, **48**, 433-43, 493-506, 1940.
[3] Spencer, L. J., *Geog. Jour.*, **81**, 227-42, 1933.
[4] Suess, F. E., *Neues Jahrb. Min., A*, **72**, 98-155, 1936, and Stutzer, O., *Zeits. Deutsch. Geol. Ges.*, **88**, 523-5, 1936; Hammer, W., *Verh. Geol. Bundesanst.*, Wien, 1937, 195-206, 268-9, and Kranz, W., *Neues Jahrb. Min., B*, **80**, 113-18, 1938.
[5] Maclaren, M., *Geog. Jour.*, **78**, 270-6, 1931; Junner, N. R., *Rep. Geol. Surv. Gold Coast*, 1932-33, 4-7, and *Bull. Geol. Surv. Gold Coast*, No. 8, 5-37, 1937.
[6] Kaljuvee, J., *Die Grossprobleme der Geologie*, 1933, and Kranz, W., *Petermanns Geog. Mitt.*, **83**, 198-202, 1937.
[7] Rohleder, H. P. T., *Zeits. d. Deutsch. Geol. Ges.*, **85**, 463-8, 1933, and *Geol. Mag.*, **70**, 489-98, 1933.
[8] Melton, F. A., and Schriever, W., *Jour. Geol.*, **41**, 52-66, 1933, and McCarthy, G. R., *Bull. Geol. Soc. Am.*, **48**, 1211-26, 1937; Cooke, C. W., *Jour. Geol.*, **42**, 88-96, 1934; Millman, P. M., *Jour. Roy. Astr. Soc. Canada*, **30**, 57-9, 1936; and Watson, F., Jr., *P. A.*, **44**, 2-17, 1936.
[9] Heide, F., *Naturwiss.*, **26**, 495, 1938.
[10] Lake Bosumtwi, *e.g.*, lies on the "Lacroix-Spencer locus"; *cf.* La Paz, L., *C.S.R.M.*, **2**, No. 1, 28-34; *P. A.*, **46**, 224-30, 1938.
[11] Reinvald, I., *The Sky*, **2**, 6-7, 28-9, 1938, and Spencer, L. J., *Min. Mag.*, **25**, 75-80, 1938.
[12] Spencer, L. J., *Min. Mag.*, **25**, 432, 1939.
[13] *Cf.* ref. (12), p. 438.
[14] Dirac, P. A. M., *Die moderne Atomtheorie* (by W. Heisenberg, E. Schrödinger, and P. A. M. Dirac), 45, 1934, Leipzig.
[15] Gamow, G., *Structure of Atomic Nuclei and Nuclear Transformations*, 14, 1937, Oxford.
[16] Rojansky, V., *Phys. Rev.*, **48**, 108, 1935; *Astroph. Jour.*, **91**, 257-60, 1940.
[17] Zwicky, F., *Proc. Nat. Acad. Sci.*, **22**, 266, 1936.

The "Phantom Bertha" Mystery

By SAMUEL HERRICK, JR.,
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ABSTRACT

A newspaper account of a mysterious explosion at sea is reviewed and shown to be not inconsistent with the supposition that the explosion may have been due to the fall of a contraterrene meteorite. Attention of astronomers and meteoriticists is called to this and other types of phenomena which they may have to investigate in the light of the hypothesis of the existence of contraterrene matter.

Sherlock Holmes is quoted by his biographer on at least two occasions as admitting, with something like pride, a thoroughgoing ignorance of astronomy.[1] "If we went around the Moon [instead of the Sun]," he says, "it would not make a pennyworth of difference to me or my work." Astronomers who have long smarted under this slight to their profession may be grateful jointly for the hypothesis of the existence of contraterrene meteorites, as reported and elaborated upon in

the foregoing article by Dr. La Paz, and for the Holmes-challenging mystery recorded in *The New York Times* of September 15, 1940,[2] under the headline: "PHANTOM BERTHA SHELLS SOUND BOAT." We quote the article in part as follows:

"As the 22-foot cutter-type sailboat *Rockit II* was crossing Long Island Sound near Bridgeport, Connecticut, yesterday morning with four peaceful persons aboard, a shell screeched across her bow and exploded in the water a hundred yards away.

"On the boat were the owner, George Seward, an official of the Connecticut Mutual Life Insurance Company, 233 Broadway, New York; his wife; their 3-year-old daughter; and Edward C. Hayward, also of the Connecticut company, who lives at 112 East Eighty-first Street . . .

" 'We turned on the radio to hear the 10 A.M. news broadcast,' Mr. Hayward explained later. 'I suppose we were all thinking about what was going on in London. But the Sound was peaceful enough; the breeze was good and the water wasn't rough at all. Mrs. Seward was on deck, her husband had gone below, and their daughter was with me when the thing happened.

" 'The screech came first—an unholy noise. Then, a split second later, the explosion, about two points off the starboard bow. It blew up a great tower of water, twenty or thirty feet in the air. It was the strangest thing in the middle of that peaceful Sound. Why, there wasn't even a boat in sight! And not an airplane overhead!

" 'I brought the boat parallel to the shore with the thought in mind that, if some sort of target practice were going on, an observer would be able to see our sail broadside. Then we all put on life preservers and made for Port Jefferson as fast as we could. We started the motor and cleared out of that place.'

"Mr. Hayward estimated that the shell landed some time between 10:10 and 10:15 A.M. The *Rockit* was in sight of Long Island at the time, but the Connecticut shore was not visible. He is certain the shell came from Connecticut, both from the direction of the screech and from the fact that the water that was kicked up fell to the southward.

"At Coast Guard headquarters in New York, officials said there were no stations in that immediate area. National Guard officials at Bridgeport said none of their units was engaged in any artillery practice. There are no proving grounds in the vicinity. Small arms are manufactured in Bridgeport, notably at Remington Arms, but a spokesman for that company asserted that nowhere in the neighborhood were artillery shells being manufactured, although some parts were made for full assembly elsewhere.

"The Remington official suggested that perhaps a practical joker had supplied live ammunition for the starting gun in a regatta on the Sound. There were boat races on that water yesterday, but all of them so far away that the starting gun would have had to be a Big Bertha to put a projectile off Bridgeport.

"As to the possibility that the object was not a shell at all, but was perhaps a meteorite, it was said at the Hayden Planetarium that a meteorite on striking water would not explode."

The hypothesis of the existence of contraterrene meteorites bids fair to contradict the closing statement of this article, since a contraterrene meteorite large enough to penetrate the Earth's atmosphere would produce, upon reaching the surface of the sea or land, just such an explosion as that which was reported by the crew of the *Rockit*.[3] "History repeats itself"; astronomers and meteorite-chasers who have made statements such as that attributed to the Hayden Planetar-

ium—and quite possibly they are numerous—may find themselves in the embarrassing position of the Académie des Sciénces of Paris, which pronounced false early reports that stones, now known to be meteorites, had fallen from the sky.[4] In any event, Mr. Sherlock Holmes, if he investigates the "Phantom Bertha" mystery, will have to open his storehouse of information to the science of astronomy and in particular to the papers of La Paz and Rojansky.[5] Investigators of alleged meteorite falls, moreover, will be able no longer to turn away when it is reported that "the meteorite exploded upon striking the ground." It is very much to be feared that they will have to become experts on powder stains and the residua of firecrackers before they can be sure of themselves in classifying such phenomena as non-meteoritic!

Messrs. Dirac, Gamow, Rojansky, and Zwicky[6] are to be congratulated on one of the most ingenious (and entertaining) hypotheses of recent years. The tremendous radiant energy that would result from the collision of atoms in which the nuclei are charged negatively and the extra-nuclear members are positrons (contraterrene atoms) with ordinary (terrene) atoms provides us with a field for hopeful speculation in connection with many astronomical phenomena. Among others may be listed those greatest of explosions, the novae and supernovae (a rather obvious conjecture which occurred to Dr. Leonard and the writer simultaneously upon reading Rojansky's second paper), cosmic rays (as discussed by Zwicky and Rojansky), and the meteoritic phenomena discussed by La Paz. Perhaps, also, meteoriticists will have to distinguish between the highly explosive fireballs or bolides from which no material reaches the ground, and which accordingly may be contraterrene, and those which are the source of terrestrial meteorites.

NOTES

[1] A. Conan Doyle, *The Complete Sherlock Holmes*, **1**, Sec. 1, 14-15; Sec. 3, 119; New York: Doubleday-Doran, 1930. See also **1**, Sec. 4, 113, 184, and **2**, Sec. 3, 148, 158, for additional astronomical references, in some of which the author betrays that Holmes's education was not purely vocational.
[2] P. 52, col. 1 of the "Late City Ed."
[3] *Cf.* the next to the last paragraph of the preceding paper by L. La Paz.
[4] C. P. Olivier, *Meteors*, p. 5; Baltimore: Williams and Wilkins, 1925.
[5] *Cf.* also V. Rojansky, *Phys. Rev.*, **58**, 1010, Dec. 1, 1940.
[6] *Cf.* references 14, 15, 16, and 17 in the preceding paper by La Paz.

Meteorites on Exhibition at the Golden Gate International Exposition

The following meteorites *etc.* constituted the collection specially assembled for the astronomical exhibit of the University of California in the Hall of Science at the Golden Gate International Exposition on Treasure Island in San Francisco Bay, during the seasons of 1939 and 1940.

(1) A 357-lb. Canyon Diablo, Arizona, siderite (lent by the Department of Astronomy, University of California, Los Angeles).

(2) A 1,229-g. slice of a Springwater, Saskatchewan, Canada, siderolite (specially purchased from the American Meteorite Laboratory, Denver, Colorado).

(3) A 640-g. piece of the Allegan, Michigan, aërolite (lent by the Lick Observatory, University of California, Mt. Hamilton).

(4) A 1,416-g. slice of the Kelly, Colorado, aërolite (purchased from the A.M.L.).

(5) A 4,267-g. slice of the Coya Norte, Chuquicamata, Chile, siderite (lent by the Department of Geological Sciences, University of California, Berkeley).

(6) A 380-g. slice of a Gladstone, New Mexico, aërolite (purchased from the A.M.L.).

(7) A 3-oz. piece of a Cumberland Falls, Kentucky, aërolite (lent by the Lick Observatory).

(8) A piece of metamorphosed sandstone from Meteorite Crater, Canyon Diablo, Arizona (lent by the Lick Observatory).

(9) The 2,573-lb. Goose Lake, California, siderite (lent by the Smithsonian Institution and the United States National Museum, Washington, D. C.).*

(10) A 7,021-g. Canyon Diablo, Arizona, siderite (purchased from the A.M.L.).

(11) A 1,034-g. slice of a Huizopa, Chihuahua, Mexico, siderite (purchased from the A.M.L.).

(12) A 6 lb., 9-oz. Plainview, Texas, aërolite (lent by the Department of Geological Sciences, Berkeley).

(13) 2 large meteorodes from the Haviland Crater, Brenham Tp., Kiowa Co., Kansas, together weighing about 4,000 g. (purchased from the A.M.L.).

(14) A 1,531-g. slice of a Brenham Tp., Kiowa Co., Kansas, siderolite (lent by the Department of Geological Sciences, Berkeley).

After the close of the fair on September 29, 1940, the specimens lent by the several institutions mentioned were returned to them, while, by action of the authorities concerned, specimens no. (2), (4), (6), (11), and (13) were allocated to the Department of Astronomy of the University of California at Los Angeles and specimen no. (10) was assigned to the Berkeley Astronomical Department of the University. F.C.L.

*3 excellent, full-size models of this great iron, fabricated at the California Academy of Sciences in San Francisco, have been for some time on exhibition at the Academy, the Chabot Observatory in Oakland, and the Griffith Observatory in Los Angeles, respectively. A fourth one (for the writer) is now under construction. Each is said to weigh "somewhere in the neighborhood of 250 lb."

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Some Phases of Celestial Mechanics that Astronomers have Overlooked

In previous contributions to POPULAR ASTRONOMY I have written about problems in celestial mechanics overlooked by astronomers, the solutions of which explain many phenomena observed in the solar system, including terrestrial phenomena, not adequately explained in scientific works. These contributions are the following: "The Sun's Heat," March, 1933; "Centrifugal Force and the Tides," August-September, 1934; "A Mechanical Explanation of Light and Related Phenomena," December, 1936; "Tidal Waves and Ocean Currents," April, 1936; "Comets, Their Origin and Behavior," April, 1938; "Sign Posts and the Earth's Magnetism," October, 1939

The recession of the line of apsides of the planet Mercury in a century amounts to a fraction of a degree more than can be accounted for by Newton's laws. Professor Einstein makes the claim that this is a demonstration of his theory as opposed to Newton's. Astronomers tell us that if there were a planet

between Mercury and the sun, or better a swarm of satellites, this apparent irregularity in the course of Mercury would be accounted for. The fact is that there are three things that may be considered the equivalent of a swarm of satellites between Mercury and the sun. However, determination of their mass is not possible. I refer first to the equatorial protuberance of the sun due to its rotation, second to the protuberances caused by the gravitational pull of Jupiter (and to some extent by the earth and Venus). The third, and most nearly equivalent to a swarm of satellites, is the sun's atmosphere. This is deeper at the equator than at the poles, and it is rotating or revolving at a much greater speed than the body of the sun itself.

That the sun's atmosphere is deeper over the equator than at the poles and is revolving in an eastern direction are facts the former of which is shown in total eclipses and the latter of which has been observed spectroscopically. Mechanically both of these can be reasoned out in the following way.

The surface of the sun is in a continuous state of ebullition in the middle or equatorial belt, because this belt is subject to rotation at a greater angular velocity than the main body itself, due to the influence of the planets and frictional generation of the extra heat. That is the cause of volcanoes (sunspots) in that belt. This heat activity causes gases and finely divided matter to be forced out into the space surrounding the sun, and these turbulent gases constitute the sun's atmosphere, deeper over the equator than near the poles, probably about one or two million miles in depth.

Because of the rotating influence on their primaries and any fluid substance in the plane of the satellite's orbit, of all satellites, the sun's upper atmosphere, as is the earth's, is moving swiftly in an eastward direction. The surplus depth of atmosphere in the sun, rotating as it does, presents the equivalent of a swarm of planets close to the sun, and this is a complete explanation of the aforementioned irregularity in the movement of the line of apsides of Mercury.

Small disturbances in the course of the moon could probably be accounted for in the "tide" protuberances of the earth raised by the influence of the moon. And I do not mean by the water wave that the moon is supposed to raise "crosswise" with the alleged tidal force; I mean the protuberances in the body of the earth itself on the side of the earth toward the moon and the opposite side. The water wave, as I have shown in one of the references cited, is merely incidental to the real upheaval, which more than a hundred thousand careful observations on the polar distances of stars at transit have proven to occur, namely an upheaval in the body of the earth itself.

Astronomers have failed to grasp the fact, proven by these stellar observations, that the apparent star shifts are completely explained by a knowledge that the effect of the moon on the solid body of the earth is to elongate its diameter in the direction of the radius vector of the moon. Not only is the observed four-times-a-day rise and fall or heaving explained when the moon is near the earth's equator, but also the observed twice-a-day heaving when the moon is near its extreme northern or southern latitude.

The explanation is a simple one. When the moon is near the equator, the rise in the earth's surface is of course greatest at the equator and less in the temperate zone, where telescopes are located. A high and low point, each of equal amounts, occurs twice a day, or a rise and fall and a rise and fall in each of the moon's days of 25 hours. When the moon is near its maximum northern or southern latitude, the main protuberances are in opposite hemispheres (northern and southern).

Naturally, the protuberance in the northern hemisphere, which comes into the latitude of a telescope at intervals of 25 hours, will have a predominating effect in showing the apparent displacement of a star (in its polar distance), while the one in the southern hemisphere, being so much farther south of a given telescope (in the north temperate zone), will show but little displacement. Hence the twice-a-day variation.

To understand the effect on a telescope of the protuberances caused by the pull of the moon *on the body of the earth,* it is only necessary to imagine a rubber sphere with pins stuck into it pointing to the center of the sphere. Suppose some force raises the surface near a pin, the pin will no longer point exactly to the center of the sphere, but a little to one side. These pins represent the zenith axis of the telescope.

The apparent discrepancy in time difference, shown in transit of stars, between America and Europe, also observed, is fully explained by exactly the same reasoning, and is due to the moon-induced protuberances already referred to.

EDWARD GODFREY.

Professional Building, Pittsburgh, Pennsylvania., December 23, 1940.

General Notes

Dr. Daniel Walter Morehouse, President of Drake University at Des Moines, Iowa, died on January 21 of pneumonia and heart disease. Dr. Morehouse was well known in the field of astronomy as the discoverer of two comets as well as for other astronomical work.

Dr. Adriaan van Maanen, of the Mt. Wilson Observatory, according to an announcement by Dr. Walter S. Adams, Director, has recently discovered that two additional stars are relatively near to the sun. They are the stars Ross 128 and Luyten 789-6. The distances given for these stars are 11.3 light years and 10.3 light years, respectively.

Robert Millford Motherwell, well known in astronomical circles in Canada for a number of years, died suddenly on September 30, 1940. Mr. Motherwell had studied at the Yerkes Observatory and elsewhere and made astronomy his profession. However, he was much interested in other lines of service such as Y.M.C.A. work, membership on many boards of the United Church, and the promotion of boys' and girls' camps in Ontario and Quebec.

Dr. Frederick C. Leonard, Chairman of the Department of Astronomy of the University of California at Los Angeles, will serve as visiting professor of astronomy in the summer session of the University of British Columbia, Vancouver, B. C., Canada, July 7 to August 22, 1941, while Dr. Daniel Buchanan, Dean of the Faculty of Arts and Science and Head of the Department of Mathematics of the University of British Columbia, will be a member of the faculty of the summer session of the University of California at Los Angeles, June 30 to August 8, as visiting professor of astronomy and mathematics. This will be the third time that Dean Buchanan has come to the University of California at Los Angeles and Professor Leonard has gone to the University of British Columbia for the period of

the summer session, a similar exchange having been made by them in 1937 and in 1939.

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on Friday, January 10, 1941, at the Lecture Hall of the Franklin Institute. Dr. Arthur E. Bassett, retiring president of the Rittenhouse Astronomical Society, gave his presidential address to the Society on the subject "A Layman Looks at Astronomy and Astronomers."

Dr. George Rosengarten was inducted as new president of the Society. Astronomical motion pictures also formed a part of the program.

The Hume Cronyn Memorial Observatory

The Journal of the Royal Astronomical Society of Canada for November, 1940, contains an account of the dedication on October 25 of the Hume Cronyn Observatory at the University of Western Ontario. This observatory consists of a beautiful two-storied, stone structure surmounted by a dome. The principal instrument is a refracting telescope of 10-inch aperture. Other supplementary apparatus designed chiefly for instruction and for acquainting the public with the elementary phases of the science are also included. The University of Western Ontario is to be congratulated upon this significant addition to its equipment. The observatory is under the direction of Dr. H. R. Kingston.

Summary of Sun-Spot Observations at Mount Holyoke College, 1940

Month	No. of Obs.	North of Equator No. of Groups	North of Equator Av. Lat.	South of Equator No. of Groups	South of Equator Av. Lat.	Av. No. Groups at one Obs.	New Groups
January	11	5	+14°.2	8	—11°.1	3.2	13
February	16	10	11.9	16	9.0	4.7	23
March	10	8	14.9	12	7.6	4.6	13
April	16	11	9.0	12	9.1	4.6	23
May	16	9	11.5	12	10.2	3.4	20
June	9	4	13.8	11	10.3	5.3	12
September	12	8	14.9	5	8.2	3.9	13
October	22	8	11.8	11	9.4	4.2	17
November	16	10	12.4	10	12.0	4.2	19
December	11	11	11.1	17	8.1	7.0	26
Totals	143	84		114			179

Average number of groups at one observation	4.39
Average latitude of spots north of equator	+12°.6
Average latitude of spots south of equator	— 9.5

The figures show a decided decrease in activity since 1939. The average number of groups at one observation has dropped from 6.56 in 1939 to 4.39 in 1940. The total number of new groups is considerably less than last year. On no day of observation was the sun free from spots. No record was kept from June 15 to September 15. The spots are 2°.4 nearer the equator in northern latitudes and 2°.7 in southern latitudes. On April 19, November 7, and November 8 a group was recorded as being in latitude 0°.

The observations through June were made largely by Miss Edith Jones and Miss Barbara Bilsborough. The remainder of the observations were made by Miss Jocelyn Gill.

HELEN SAWYER HOGG.

John Payson Williston Observatory, January 16, 1941.

Book Reviews

Your Mind and Mine, by J. C. Cattell. (The Scientific Book Club, 121 Charing Cross Road, London. 2/6 to members.)

So far as its presentation ventures to go "Your Mind and Mine" written by Raymond B. Cattell, psychologist to the City of Leicester Education Authority, (date of copyright and of publication unrevealed) is essentially sound. And it is interesting. Being interesting is, I should say, its peculiar virtue. For every book in the field of psychology which is interesting to the lay reader there are scores which are essentially sound. I know of no contemporary author who more richly deserves for himself that portion of the famous phrase which a generation ago gave the honors to William James at the expense of his literary brother Henry: "He writes his psychology as if it were a novel." Most attempts to popularize accounts of psychological findings have involved endless inaccuracies and not a few have involved downright misconceptions. Most attempts to be accurate have been dull. Here is a book which offers good reading as judged by both criteria.

While a wide variety of topics has been selected for consideration and while these varied topics are for the most part comprehensively integrated, the publishers palpably overstate their case when they say that "no important branch of pure or applied psychology has been neglected." No book of 309 pages could make good a claim so sweeping as that. The blurb challenges one to call to mind at random such "branches" as psychometrics, attention, motivation, Gestalt psychology, maturation and learning, imitation, habit, measurement of attitudes, esthetics, and the vast field of sensation and perception. To mention such omissions is not to condemn the book. Perhaps no presentation, however extensive in scope, should attempt to cover so much as is claimed for this book. It is remarkable rather that the author has brought into one consistent account such varied points of view as those of the physiologist, the probation officer, the statesman, the educator, the alienist, the industrialist, the philosopher, of Gall, Lashley, Plato, Binet, Watson, Spearman, Pavlov, Bergson, Kretschmer, and the Freudians.

The magnet within whose fields these widely varied points of view are polarized seems to be Shand's theory of what he calls sentiment. This is defined in Warren's *Dictionary of Psychology* as "an acquired disposition to certain types of emotional experience and action, in relation to some one object or to any object of some one kind." The notion, as worked out in much detail by McDougall and as reviewed in considerable detail in this book, offers a convenient point of view from which one not technically familiar with the lay of the land may survey the bewilderingly varied data of modern psychology. Such a reader should be reminded only that there are other points of view which may serve the same convenient function.

L. A. Headley.

Carleton College, Northfield, Minnesota.

Contributions of the Los Angeles Astronomical Department of the University of California.—This is to announce that Vol. 1, No. 1, pp. 1-56, of *University of California Publications: Contributions of the Los Angeles Astronomical Department,* has just (December 26, 1940) been issued from the University of California Press, Berkeley and Los Angeles. The Board of Editors of the new

series consists of the three permanent members of the Department, Dr. Joseph Kaplan, Dr. Samuel Herrick, Jr., and the undersigned, as Chairman. Vol. 1, No. 1, is entitled, "The Laplacian and Gaussian Orbit Methods," and is by Dr. Samuel Herrick, Jr. This series is designed to contain all papers originating in the Department of Astronomy at Los Angeles that are to appear in the publications of the University of California.

FREDERICK C. LEONARD, *Chairman,*
Department of Astronomy.
University of California, Los Angeles.

Stars and Men, by Stephen A. and Margaret L. Ionides. (The Bobbs-Merrill Company, Indianapolis and New York. $4.00.)

The number of books written for the purpose of bringing the recent developments of astronomy, as well as the historical aspects of the subject, within reach of the general reader is increasing very rapidly. The field is so vast and the methods of approach so numerous that each new writer in turn is able to present the material from a somewhat new point of view. The volume before us fits nicely into this growing literature and affords instruction and entertainment throughout its more than four hundred pages.

The two nouns in the title at first seem hard to reconcile in such a setting. It seems there is little that they might have in common. After reading the volume, one feels that the juxtaposition of these words has been fully justified. Although the stars are quite hot, they may still be said to be coldly remote. But, except for the mind of man, they would remain in their isolation, mysterious and, to the untutored person, possibly of baneful significance. But man has been able to arrive at the point at which he may be said to have a partial understanding of them, at least. Hence man has made friends with the stars.

The personal and human touches throughout the volume add much to its value and charm. The apt quotations which introduce the chapters give the reader a hint of what is to follow. The illustrations, seventy-four all told, also contribute to make the presentation vivid and interesting. The chronology at the end is a convenient compilation of dates from 4500 B.C. to 1934 A.D. The glossary, which follows the section on chronology, will be exceedingly useful to those who may be confused by a new terminology.

We have mentioned a few of the obvious features of this volume. A careful reading will reveal many other equally commendable ones. The reader is impressed with the widee acquaintance of the writers with ancient, scientific, mythological, and historical literature. Withal the volume is beautifully bound and will therefore be a decorative as well as a useful addition to any library.

Troubadour of the Stars, by Olaf Saile. (Oskar Piest, 250 West 57th Street, New York, N. Y. $2.50.)

It would probably require an extensive knowledge of history and astronomy, as well as a certain poetic sensitiveness, to discover the personality described by the title given. Possibly a realization of this prompted the secondary title, "The Romantic Life of Johannes Kepler." Having learned the name of the "Troubadour" the reviewer then had to adjust his thinking to that aspect of Kepler, the great astronomer. Up to that time he unconsciously had regarded Kepler as completely described and accounted for by the epoch-marking laws of planetary motion which are associated with his name. It was as though Johannes Kepler had always been a mature person with an intellect capable of penetrating more deeply than any

other into the mysteries of the movements of the heavenly bodies. It is, therefore, somewhat of a surprise to learn that, instead of a life of tranquility and complete absorption in a contemplation of the remote and orderly planets, throughout his fifty-nine years he was constantly beset with troublesome family difficulties and turbulent political situations. During the last twelve years of his life the Thirty Years War was raging in Europe. As the Imperial Mathematician he was brought into close range with the happenings at Court, and his fortunes were necessarily intimately bound up with them. In consideration of the things he did accomplish, one is led to conjecture as to how much farther he might have advanced the science of his day, had external conditions been more favorable.

As the titles indicate, this volume stresses the personal characteristics of the subject rather than his scientific achievements. Even the three laws, already referred to, are not formally stated. As such it, therefore, constitutes a pleasing and desirable supplement to the many scientific treatises concerning him. Readers, who might be deterred from attempting an acquaintance with this genius because of the austerity with which his prominent place in astronomical development surrounds him, will find in this volume a well presented account of an exceedingly human personality.

Copernicus, The Founder of Modern Astronomy, by Angus Armitage. (W. W. Norton & Company, Inc., 70 Fifth Avenue, New York, Distributors. $3.00.)

Students of systematic courses in astronomy or even casual readers in that field are sure to have their attention called to the work of Copernicus and to the influence which he exerted in the development of that science. They learn that his epoch-making volume was called *"De Revolutionibus Orbium Coelestium,"* and that it was published at the close of his life. In fact an advance copy was put into his hands only a few hours before his death. This is about as close as most students come to the work. The Latin text is not a suitable medium for many present-day students to work with.

The author of the volume before us has made it possible to surmount this difficulty and to deal quite intimately with the original writings of Copernicus. The first chapter presents a summary of cosmological theories from the earliest records to the time of Copernicus. The second is devoted to the life-story of Copernicus and teaches us that he was trained in medicine, law, and theology, and made contributions in those fields also. The remainder of the book is concerned with the details of the Copernican theory and the current theories which it had to contend with. Close and attentive reading is required for its comprehension, but one reads it with the confidence that it is authoritative and the feeling that it is elucidating.

Science, Today and Tomorrow, by Waldemar Kaempffert. (Ivor Nicholson & Watson, Ltd., 7 Paternoster Row, London E.C.4. 10/6 net.)

This volume was published early in 1940 and hence at this time, even though progress in science is rapid, is still quite up to date. The author, due to his position as Science Editor of the *New York Times,* writes from a decided point of vantage and in a style which commends itself to the average reader.

Since the field of present-day science is very large, no single volume can include all of its aspects. The author in this instance limited his topics to eighteen, ranging from the rather abstract and remote one "A Star Explodes" to the practical and present one "After Coal—What?" His discussion of these eighteen topics fills 243 pages with interesting and informative material. The chapters form dis-

tinct units and may, therefore, be read in any order. It is felt by the reviewer that his experience will doubtless represent that of any one who begins the reading of this book, namely, that he will not be content until he has read all of the chapters. The reviewer intended to mention a few topics as typical, but finds himself unable to decide which titles to omit, so following is the complete list: A Star Explodes, The Sun: New Aspects, Birth and Death of the Moon, Life in the Solar System, Rocketing through Space, Explorers of the Atmosphere, The Mystery of the Atom, After Coal—What?, The Chemical Revolution, Can the Laboratory Create Life?, Evolution since Darwin, Carrel, Man and His World, Jove's Competitors, Speed, A Liner leaves Port, Electric Immortality, Democracy and its Machine.

For all who wish to keep abreast of the developments and trends in modern science along the lines indicated by the above topics, this book is highly recommended.

Handbook of Mathematical Tables and Formulas, (Second Edition), by Richard Stevens Burington. (Handbook Publishers, Inc., Sandusky, Ohio. $1.25 postpaid.)

In the Burington Handbook there is assembled in convenient form an unusual collection of mathematical formulae and tables. The most optimistic collegiate reference needs appear to have been anticipated, and in addition valuable computational helps are included. Thus, in the first part of the book, in addition to the usual algebraic formulae, trigonometric relations, plane and solid analytic geometry, and calculus theorems, there are hyperbolic functions, vector analysis, and a table of 434 integrals. In the second part of the book some of the less usual tables include a seven-place table of logarithms of numbers 10,000 to 12,000, a table of important constants—some to 21 significant figures—and their logarithms to seven places, tables of trigonometric functions for decimal fractions of a degree and for radians, tables of factorials and their logarithms, a table of common logarithms of Gamma Functions, a table of probability functions, and a table of complete elliptic integrals.

Carleton College, Northfield, Minnesota. R. B. Q.

Punched Card Methods in Scientific Computation, by W. J. Eckert. (The Thomas J. Watson Astronomical Computing Bureau, Columbia University, New York City.)

This book, bearing the publication date January, 1940, is probably the first of this kind to be published. Within a generation the extensive work of numerical computation has been shifted from logarithmic tables to computing machines which are well-nigh automatic and well-nigh infallible. In the last decade the machine processes have been still further refined with the result of wider application and greater speed. This extension requires greater complexity in the machines and greater skill and insight on the part of the operator. This has led to a centralization of this kind of work at Columbia University under the direction of the author of the book. The author's interest in astronomy doubtless accounts for the fact that the modern methods of computation have been applied with marked success to work in astronomy, notably the Yale Star Catalogues and to checking the monumental work on the moon by the late Ernest W. Brown. The methods, however, are applicable to problems in other fields as well, but are profitable only in case a large number of similar problems are to be solved.

The reading of the book would, no doubt, be done more intelligently if a setup were at hand for illustration. But even without that one is impressed with the facility by which complicated processes are carried through and with the wide variety of application.

The author having recently been appointed director of the *American Ephemeris and Nautical Almanac* thus finds himself in a situation in which his computing methods may be used to great advantage and probably on a scale such as is afforded by no other single enterprise.

Spectra of Long-Period Variable Stars, by Paul Merrill, pp. 107 + ix. (The University of Chicago Press, Chicago, Illinois. $2.50.)

Two years ago Dr. Merrill published a little book on the Nature of Variable Stars, with the purpose of summarizing our knowledge of variable stars and of assisting the non-technical reader to a comprehension of the general nature of modern astrophysical studies. All classes of intrinsic variables were treated for obtaining a basis for a picture which emphasized the significance of the study of variable stars for our knowledge of the structure and the evolution of the stellar system. If one wishes to compare Merrill's new monograph with his earlier book, it can be said that it is restricted to the one class of long-period stars, and, indeed, only to their spectra, but that, on the other hand, it offers a welcome extension for the special study of that field in which for many years the author has worked with greatest success and has made the most outstanding contribution to our knowledge.

The book has seven chapters. The first of them, Introductory, gives the definitions of the long-period variables as described by several authors. Chapter two is an historical sketch of our knowledge of the spectra, beginning with the pioneer work of Secchi, Vogel (whose earlier observations were made at Bothkamp, not at Potsdam), Dunér, Pickering, and others who observed visually. This was the first of three great periods. The second period comprises photographs with objective prisms, almost exclusively the domain of the Harvard Observatory; the third era was inaugurated with the application of slit spectrographs, attached to large telescopes, to more detailed and precise investigations. Chapter three contains the numerous facts about the spectra at maximum-light, the sub-titles being: spectral energy curves, bands (classes M, S, and N and R), absorption line-spectrum, and bright lines. Of course much more observational material is available for this chapter than for the next: Variation with phase. Some special problems, as displacement of dark and bright lines, structure and origin of bright lines, are discussed in chapter five, and the sixth treats some individual variables of special interest: Mira Ceti, X Ophiuchi, R Aquarii, χ Cygni, W Hydrae, and RW Hydrae.

In the seventh chapter, entitled general problems, the author discusses the probable causes of variability. He includes (a) change of the radiating area, (b) change of temperature of the photosphere, (c) effect of absorption bands, and (d) veiling. No one of these causes alone is sufficient to explain the total loss of brightness. The mean visual range of advanced M-type variables is six magnitudes. For this variation (a) cannot be significant, (b) may contribute three magnitudes, (c) two magnitudes, and (d) one magnitude. For S-type variables, whose bands are less conspicuous, veiling may be of relatively greater importance.

Merrill's book offers an excellent guidance to the student of the field For all the observational and other data there are given references, far more than 200 altogether, so that it likewise may be used as valuable bibliography. The book, al-

though written for the scientist, may be studied also by a non-technical person with great advantage.

R. PRAGER.

Harvard College Observatory.

John Alfred Brashear, by Harriet A. Gaul and Ruby Eiseman. (University of Pennsylvania Press, Philadelphia. $2.25.)

This volume of 210 pages is the third in a series known as "Pennsylvania Lives." This series is evidently intended to preserve for posterity the contributions made to the State of Pennsylvania, to the nation, and to humanity by certain prominent citizens. Anyone who had the privilege of an acquaintance with John Alfred Brashear, or "Uncle John" as he was affectionately known, sees at once the appropriateness of including his biography in a series with such a purpose. The account of the gradual development from boyhood to manhood and to maturity of one whose beginnings were so humble and accomplishments so grand not only affords fascinating reading but also furnishes encouragement and inspiration.

A beautiful touch throughout the book is the spirit of understanding, interdependence, and coöperation between "Uncle John" and his wife, Phoebe. So potent was the influence of Phoebe Brashear throughout her entire life in the unfolding of the latent powers of "Uncle John" that the title of the book might well include both names. It is practically certain that "Uncle John" would have been the first to suggest it.

Briefly, "Uncle John" advanced from a worker in the steel mills to a maker of scientific instruments of the greatest precision, to an educator as president of what is now the University of Pittsburgh, to an administrator through membership on many Boards, to a philanthropist in connection with the wealthy persons in Pittsburgh, to the leading citizen in the State of Pennsylvania in 1915. His name and fame had spread to Europe and to the Orient to such an extent that his visits to these foreign parts after he had reached his seventies became triumphal marches.

These two exemplary citizens, "Uncle John" and Phoebe Brashear, early in life acquired a love for the stars and this motive remained as the dominating one as long as they lived. Therefore, no more fitting epitaph could be devised for them than the one which may now be seen in the crypt of the Allegheny Observatory where their ashes have been placed:

We have loved the stars too fondly
To be fearful of the night.